OFFICE OF INTERNATIONAL
AGRICULTURAL PROGRAMS
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STRENGTHENING GRANT

SELECTED PROCEEDINGS
OF KANSAS STATE UNIVERSITY'S
1986 FARMING SYSTEMS RESEARCH SYMPOSIUM

FARMING SYSTEMS RESEARCH & EXTENSION: FOOD AND FEED

Edited by
Cornelia Butler Flora & Martha Tomecek

Paper No. 13 October, 1986

FARMING SYSTEMS RESEARCH

PAPER SERIES

KANSAS STATE UNIVERSITY
MANHATTAN, KANSAS 66506 U.S.A.

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FARMING SYSTEMS RESEARCH PAPER SERIES

Kansas State University's Farming Systems Research (FSR) Paper Series is supported by the U.S. Agency for International Development Title XII Strengthening Grant. The goal of the Strengthening Grant is to increase the University's ability to implement Title XII agricultural and nutritional development assistance programs in less-developed countries. This series is maintained by the FSR Program Associates — a multidisciplinary team of professors who are aiming their activities at applied research on farming from a systems perspective.

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SIXTH ANNUAL FARMING SYSTEMS RESEARCH AND EXTENSION SYMPOSIUM

OCTOBER 5-8, 1986

KANSAS STATE UNIVERSITY, MANHATTAN, KANSAS

FARMING SYSTEMS RESEARCH AND EXTENSION: FOOD AND FEED

CO-SPONSORED BY: THE OFFICE OF INTERNATIONAL AGRICULTURAL PROGRAMS,
KANSAS STATE UNIVERSITY, FORD FOUNDATION AND
THE FARMING SYSTEMS SUPPORT PROJECT, USAID

SYMPOSIUM PLANNING COMMITTEE

Cornelia Butler Flora, Co-Chair
William J. Jorns, Co-Chair

Meredith Smith
Vernon Larson
L. V. Withee

We gratefully acknowledge the financial assistance of the Ford Foundation.

All sessions are in the K-State Union, unless otherwise indicated.

PRE-SYMPOSIUM WORKSHOPS
Saturday, October 4

2:00 pm Sat. through 12:00 Noon Sun.	Intra-Household Workshop R. Norem	Room 202

REGISTRATION & PRE-SYMPOSIUM WORKSHOPS
Sunday, October 5

1:00- 8:00 pm	Registration	University Ramada Inn
1:00- 5:00 pm	Non-Traditional Experimental Designs for On-Farm Systems Experiments in FSR C. Lightfoot & R. Repulda	Big Eight Rm
3:00- 5:00 pm	Overview of Consumption/Nutrition Issues in FSR: A Panel Discussion Presiding: M. Smith Panelists: K. DeWalt, R. van Hefton, P. O'Brien-Place, M. Prehm, P. Meites & N. Axinn	Room 212
5:00- 7:00 pm	Communications & FSR/E: The Inside Slant J. Bemis & G. Graham	Ramada Inn, Executive VIP Room
8:00- 9:30 pm	No-Host Reception	University Club Ramada Inn

REGISTRATION & PAPER SESSIONS
Monday, October 6

7:30-12:00 am	Registration	2nd Floor Concourse
8:45- 9:00 am	WELCOME Walter Woods, Dean of Agriculture, Kansas State University	Little Theatre
9:00- 9:50 am	FOOD AND FEED The Puebla Project as an FSR Approach Presiding: V. Larson	Little Theatre

MONDAY, OCTOBER 6

	The Puebla Project -Overview L. Jimenez	
	Maize Grain and Stover Production and Use for Humans and Livestock in Small Farming Units of Puebla R. Mendoza R., A. Turrent F. & X. Chavez C.	
9:50-10:20 am	Break	2nd Floor Concourse
10:20-12:00 am	FOOD AND FEED - Puebla Project (Cont'd) Presiding: M. Lapping	Little Theatre
	Fertilizer Rates for Alfalfa Grown Under Rainfed Conditions and Milk Cows Alfalfa Requirements in the Puebla Project A. Turrent F., N. Estrella Ch., R. Mendoza, P. Claro C. & C. Barcenas	
	Performance of an Underground Granary in a Subhumid Tropical Region of Mexico A. Turrent F., S. Uribe G. & R. Camacho C.	
	Refining and Adapting an Advanced Traditional Farming System of the Mexican Highlands to an Ejido of the Subhumid Tropics A. Turrent F., R. Camacho C. & S. Uribe G.	
	Corn Yields Seasonal Variability in Plan Puebla's Area: An Assessment of Weather and Recommended Practices Effects C. Esquivel-Alvarez	
	Liaison Between Research Priorities in a Farming System Research Project and the University J.I. Cortes-Flores, A. Turrent F., J. Diaz A. & R. Mendoza R.	
12:00- 1:30 pm	Lunch Presiding: Jim Jorns Address: "Farming Systems Devlopment; The FAO Approach" K.H. Friedrich	Main Ballroom
1:30- 5:00 pm	POSTERS	Room 205

1:30- 3:00 pm CONCURRENT PAPER SESSIONS

ADDRESSING CONSUMPTION ISSUES IN AGRICULTURAL PROJECTS — Little Theatre

COMPARATIVE APPROACHES IN THE CARIBBEAN — Big Eight Rm

ECONOMIC DATA COLLECTION — Room 212

ADDRESSING CONSUMPTION ISSUES IN AGRICULTURAL PROJECTS — Little Theatre
Presiding: K. DeWalt

Dietary Consequences to On-Farm Research in Swaziland
R. Huss-Ashmore & J. Curry, Jr.

The Celistina: The Impact of a Social Forest on Food Consumption and Nutrition in the Dominican Republic M. Smith, J. de Moya & B. Santos

Discussant: M. Prehm

COMPARATIVE APPROACHES IN THE CARIBBEAN — Big Eight Rm
Presiding: V. Chase

Comparisons of Spanish Language, Anglophone & Francophone Farming Systems Projects
J. de Moya P., Dominican Republic; V. Chase, St. Lucia; B. Clarke, Dominican Republic; G. Sullivan, Haiti; & R. Swanson, Haiti

ECONOMIC DATA COLLECTION — Room 212
Presiding: R. Bernsten

Inventory of the Type of Economic Data that FSR Teams are Collecting
Presentation & Discussion

3:00- 3:30 pm Break — 2nd Floor Concourse

3:30- 5:00 pm CONCURRENT PAPER SESSIONS

MONDAY. OCTOBER 6

ADDRESSING CONSUMPTION ISSUES IN AGRICULTURAL PROJECTS	Little Theatre
COMPARATIVE APPROACHES IN THE CARIBBEAN	Big Eight Rm
FSR/E COMMUNICATIONS MODELS & TRAINING EXPERIENCES	Room 212

ADDRESSING CONSUMPTION ISSUES IN AGRICULTURAL PROJECTS — Little Theatre
Presiding: K. DeWalt

Sustained Improvements in Nutritional Status after Small-Scale Intervention in Poultry Production O. Galal, G. Harrison, O. Metwalli, S. Hegassy, Z. Motagelli, H. Aly & H. Henderson

Private and Common Property Sources of Protein: A Dilemma for FSR/E E. Wollenberg

Discussant: G. Axinn

General Discussant: Frederico Poey

COMPARATIVE APPROACHES IN THE CARIBBEAN (Cont'd) — Big Eight Rm
Presiding: V. Chase

Panel: J. de Moya P., G. Sullivan, V. Chase, B. Clarke, & R. Swanson
Discussant: J. Stubbs

FSR/E COMMUNICATION MODELS & TRAINING EXPERIENCES — Room 212
Presiding: J. Bemis

FSR/E in the World System Context H.P. Lionberger

Discussion: K. McDermott

Expanding the Franchise: Curriculum and Training for Institutional FSR/E within a Ministry J.L. Compton

7:00- 8:30 pm	KEYNOTE ADDRESS: Achievements and Future Potential of FSR/E Hubert G. Zandstra Presiding: C.B. Flora	Little Theatre
8:30-10:00 pm	Nutrition Working Group: Methodolical Issues in Incorporating Consumption Concerns in FSR/E All who are interested are invited to participate	Room 213
8:30-10:00 pm	University of Arkansas Working Group	Room 205

CONCURRENT PAPER SESSIONS
Tuesday,October 7

8:00- 9:30 am CONCURRENT PAPER SESSIONS

TRAINING AND FSR/E	Little Theatre
POLICY AND FSR/E	Big Eight Rm
PLANTS, ANIMALS AND PEOPLE	Room 207
INSTITUTIONALIZING AN FSR/E APPROACH	Room 212
DIAGNOSIS AND LIVESTOCK	Room 208

TRAINING AND FSR/E Little Theatre
Presiding: M. Mortvedt

Basic Interviewing and Note-Taking Skills for the Informal Survey in Farming Systems Research/Extension
R.H. Norem

An Institutional Building Adaptive Research Prototype: A Case Study of Farming Systems Research/Extension Training for the Bay Region, Somalia
R.L. Smith, M.Y. Boateng, G. Long & G. Beckstrand

The 1986 FSSP Gambia Workshop: Diagnosis, Design, and Analysis J.S. Caldwell, D.B. Taylor, R. Norem, L. Walecka, G.O. Gaye & I. Jack

POLICY AND FSR/E — Big Eight Rm
Presiding: C. Flora

Basic Ideas and Strategies for CIMMYT Micro-Level Policy Research J.C. Martinez, G. Sain, M. Yates & A. Hibon

How the Analysis of Cultivation Systems Contributes to a Coherent Agricultural Development Policy: Case Studies in the Mediterranean Region A. Barello, Ph. Masson & J.J. Rochon

The Use of Action Variables in Determining Recommendation Domains CM. Jolly

PLANTS, ANIMALS AND PEOPLE — Room 207
Presiding: C. McCorkle

SR-CRSP Farming Systems Research on Family Life Strategies in the Peruvian Sierra
C. Espinoza

The Effect of Gender-Related Production Management on the Design and Implementation of Participatory Technology Validation
M. Fernandez, H. Bazalar & H. Salvatierra

Alfalfa Introduction, Animal Management and Land Tenure in an Andean Indian Village P.W. Guillet

A Typology of Peruvian Peasant Community Production Systems K. Jamtgaard

INSTITUTIONALIZING AN FSR/E APPROACH — Room 212
Presiding: R. Johnson

Institution Building for Agricultural Production Systems Research in Developing Countries R.S. Temple

Institutionalizing Farming Systems Reserch and Extension in Rwanda's Buberuka Highlands E. Rawson & R. Grosz

The Evaluation and Institutionalization of a Farming Systems Research and Extension Project in Southside Virginia M.H. Rojas & M. Joshua

DIAGNOSIS AND LIVESTOCK — Room 208
Presiding: W. Geyer

Livestock Production in the Farming System in Bangladesh M. Saadullah

Paddy, Napier and Milk Cattle: A Farming System in a Drought Prone Area of Southern India V.L. Prasad and V.M. Rao

Homestead and Homestead Crop Linkages with Livestock at Jamalpur (Bangladesh) Farming Systems Research Site M.R. Khan, S. Alam & N. Vignarajah

9:30-10:00 am Break — 2nd Floor Concourse

10:00-12:00 am CONCURRENT PAPER SESSIONS

ON-FARM TRIALS — Little Theatre

FARMER ORGANIZATIONS AND FSR/E — Big Eight Rm

PLANTS, ANIMALS AND PEOPLE — Room 207

FSR/E COMMUNICATIONS: CASE STUDIES AND PROJECT REPORT — Room 212

DIAGNOSIS — Room 208

ON-FARM TRIALS — Little Theatre
Presiding: N. Thomas

A Short Methodological Account of a Dynamic Systems Field Experiment: The Case of Legume Enriched Fallows for the Restoration of Soil Fertility, Eradication of Imperata, Improvement of Pasture and Reduction in Labor for Cultivation, in the Philippines C. Lightfoot & R. Ayaso

On Farm Testing of Improved Technologies In Southwestern Nigeria: The IITA Experience
M.C. Palada, W.O. Vogel & H.J.W. Mutsaers

Economic & Social Values of Cattle In Mixed Farming Systems
J. Eckert, N. Patrick & P. Jakees

Discussion: G. Escobar

FARMER ORGANIZATIONS AND FSR/E — Big Eight Rm
Presiding: J. Benson

A Participatory Approach in Developing an Appropriate Farming System in 8 Irrigated Lowland Villages J.G. Tan

Women and Trials Management in Botswana: Experiences with Farmer Groups D.C. Baker

Generating & Validating Research Priorities through Peasant Participation: A Case from Bangladesh A.K. Gupta

Second Generation Approaches to FSR/E
G.H. Axinn

PLANTS, ANIMALS AND PEOPLE (Cont'd) — Room 207
Presiding: C. McCorkle

Integrative Strategies of Labor Organization for Crop/Livestock Production in an Indigenous Andean Community C. McCorkle

Transhumance and Agropastoral Complementarity among Berbers in Morocco's Western Atlas L Mendes

Outreach Pilot Project: A Case Study of Small Ruminant Farming Systems Research & Extension Project in Western Java M. Gaylord & P. Bilinsky

FSR/E COMMUNICATIONS: CASE STUDIES AND PROJECT REPORTS Presiding: E. Abbott — Room 212

Communications in FSR/E Projects: Can More Effective Communication Strategies Increase Project Success? G. Graham, E. Abbott, J. Bemis, D. Esslinger, A. Ben Achure, M. Karim, T. Trail, & E. Tout

Strengthening Research/Extension & Farmer Communication Linkages in Kordofan Province, Sudan T. Trail with J. Cvancara

DIAGNOSIS — Room 208
Presiding: C. Bussing

Weed Management Studies in Intercropping Systems in Trinidad and Tobago R.A.I. Brathwaite

A Study of Farming System Constraints and Research and Extension Needs in Transkei T. J. Bembridge

Diagnostic for the Research and Transference of Technology in Agrosystems H. Navarro G.

Recommendation Domains and the Design of On-Farm Research and Extension in Lesotho M. Tshabalala & D. Holland

12:00- 1:30 pm Lunch — Main Ballroom
Lunch: Communications Food & Feedback: Sunflower Room - go through buffet line and take plates to Sunflower Room

TUESDAY, OCTOBER 7

1:30- 3:00 pm CONCURRENT PAPER SESSIONS

LINKING FOOD AND FEED Little

Theatre

FARMER PARTICIPATION Big Eight Rm

ON-FARM TRIALS Room 212

LINKING FOOD AND FEED Little
Theatre
Presiding: H. Manges

Contribution of Cropping Systems Program's Research and Extension on Rural Poor: A Case Study of Ratnanagar Cropping Systems Site J. Timsina & M. Suvedi

Linkage Experiences in a Farming Systems Research Program in Lesotho C.J. Goebel, V. Ramakhula & J.A. Tiedman

Rice, Meat and Milk - System Components in North East India R. Grosvenor-Alsop

FARMER PARTICIPATION Big Eight Rm
Presiding: R. Taylor

Farmer Participation in On-Farm Research and Extension: Some Farmers Still Say "No": Lessons from the Farming Systems Development Project, Eastern Visayas (FSDP EU) T.R. Cornick, D. Alcober, R. Repulda & F. Balina

Farmer Participation in Farming Systems Research: A Jamaican Experience J. Louden, C. Reid, H. Campbell, J. Dehaney, Z. Martin, L. McBean & A.V. Chin

Producer Participation in Livestock Systems Research in the Subhumid Zone of Nigeria E. Taylor-Powell & R. von Kaufmann

ON-FARM TRIALS Room 212
Presiding: W. Kline

Evaluating On-Farm Trials of Millet-Cowpea Intercrop in Niger S. Ly, R. Deuson, K. Maliki, G. Moussa, G. Numa, C. Reddy & S. Swinton

The MARIF On-Farm Research Programme for Maize-Based Farming Systems 1984-1985 C.E. Van Santen

Responses of Wheat to Different Environments and Agronomic Practices in Context of Pakistan Cropping Systems B.R. Khan, P.R. Hobbs & D. Byerlee

3:00- 3:30 pm	Break	2nd Floor Concourse
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	CONSIDERATION OF LIVESTOCK IN FSR/E APPROACHES	Little Theatre
	FARMERS' PARTICIPATION	Big Eight Rm
	ON-FARM TRIALS	Room 212
	EXTENSION SONDEO IN ANTIGUA	Room 207

CONSIDERATION OF LIVESTOCK IN FSR/E APPROACHES — Little Theatre
Presiding: B. Koch

Market Interactions of Select Baggara Transhumants During Drought and Post Drought Periods: The Case of South Kordofan, Sudan in 1985 T.E. Gillard-Byers, B.A. Azrag & M. Speece

FARMER PARTICIPATION — Big Eight Rm
Presiding: M. Fausett

Modes of Farmer Participation in FSR/E D. Youmans with J. Henson

Assessing the Yield Gap for Alfalfa Production in Larimer County A. Fulton, R. Hamblen & W.R. Schmehl

The Potential Role of Fanner-Field Days in Integration of Research and Extension Programmes: The Experience of Adaptive Research Planning Team in Western Province, Zambia CM. Ndiyoi

ON-FARM TRIALS — Room 212
Presiding: D. Nellis

Potential of On-Farm Research Trials to Increase Crop Production on Small Farm in North Alabama D.R. Bishnoi, P. Mtshali & C. Sabota

Factors Related to the Introduction of Improved Bean, Phaseolus vulgaris, L., Cultivars for Small Scale Farmers in Morogoro Region, Tanzania E. R. Mbiha

Strategies in Designing the Second Year of On-Farm Vegetable Trials in Virginia T.J. Kalb, J.S. Caldwell, C.C. Lewis & R.W. Lacks

EXTENSION SONDEO IN ANTIGUA — Room 207

Extension Sondeo in Antigua Slide Tape & Discussion T. Henderson

6:30- 8:00 pm — Banquet — Main Ballroom
Presiding: V. Larson Address: "Women and FSR/E at IITA" N. Hahn

CONCURRENT PAPER SESSIONS
Wednesday, October 8

8:00-10:00 pm — CONCURRENT PAPER SESSIONS

FSR AND COMMODITY RESEARCH — Little Theatre

COUNTRY APPROACHES TO FSR/E — Big Eight Rm

EXTENSION — Room 212

FSR AND COMMODITY RESEARCH — Little Theatre
Presiding: F. Poston

Reconciling Conflicts in Sequential Cropping Patterns Through Plant Breeding: The Example of Cotton and Wheat in Pakistan's Punjab
D. Byelee, M.R. Akhtar & P. Hobbs

Commodity Research Team/Adaptive Research Linkages: A Zambian Example V.J. Eylands, R.E. Hudgens, S.A. Kean & C. Kefi

Use of Farming Systems Research/Extension Methods to Establish Priorities for the Horticulture Unit in the Gambia I. Jack, G.O. Gaye, J.S. Caldwell & Kuje Manneh

Decision Making in Developing and Implementing a Work Plan by FSR/E Teams F. Poey & L. Walecka

COUNTRY APPROACHES TO FSR/E — Big Eight Rm
Presiding: G. Wilde

Research and Development Programs Orientation in Mauritania S. Hamidou

Some Experiences and Achievements of Cropping Systems Research in Nepal
J. Timsima

Generating Ecology and Class Specific Research Priorities: Socio-Ecologial Perspective in FSR A.K. Gupta, N. Alam, Z. Adedin & M.M. Rahman

A Framework of Analysis for Agricultural Technology Development Utilization in Semi-Arid Africa: A Short Term Solution to Sub-Saharan Africa's Food Scarcity Crisis
K. Swanberg

EXTENSION — Room 212
Presiding: S.K. Reddy

WEDNESDAY, OCTOBER 8

Sequential Program Planning and Adaptive Research: An Application in the Nuba Mountain Area of Sudan T.E. Gillard-Byers & W.T. Bunderson

A Study of the Role of Extension in Farming Systems Research in Tanzania D. Acker & D. Sungusia

The FSR & D Extension Linkage: Experience from Mali K. Verbeek, B. Sanogo & P. Kleene

Dynamic Integration of Research & Extension Igniting the SPARC C.A. Francis

10:00-10:30 am	Break	2nd Floor Concourse
10:30-12:00 am	CONCURRENT PAPER SESSIONS:	
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	FSR/E APPLICATIONS: ADAPTING TO CONSTRAINTS	Big Eight Rm
	NUTRITIONAL IMPLICATIONS OF FSR/E STRATEGIES	Room 212
	ANIMAL-CROP INTERACTION	Room 207

FSR AND COMMODITY RESEARCH — Little Theatre
Presiding: D. Osborne

Commodity Research Linkages: A Case Study of the Tanzanian Farming Systems Project L.S. Lev

Complementing Plant Breeding with a Farming Systems Approach K.L. Buhr & D. Galt

A Quantitative Model of the Livestock System Component of a Bangladesh Farm J.R. Dickey, M.A. Jalil & M.E. Huque

FSR/E APPLICATIONS: ADAPTING TO CONSTRAINTS — Big Eight Rm
Presiding: V. Withee

Application of Farming Systems Methodology in the San Luis Valley of Colorado M. Beebe & W. Trock

Cultivation of Maize and Land Shortage: The Case of Mgeta in Tanzania J.L. Paul

The Place of Agroforestry Systems in the Tropical FSR: The Case of Initiated Agroforestry FSR and Development Program in Ghana K. Owusu-Bempah & J. Owusu-Bempah

A Farming System Development that Worked and Some that Did Not G.W. Thomas

NUTRITIONAL IMPLICATIONS OF FSR/E STRATEGIES — Room 212
Presiding: K. DeWalt

Women's Food Production Activities in an Egyptian Village Undergoing Socioeconomic Transition
N.W. Jerome, J.A. Ricci, H. Aly, S. Wahba, F. Shaheen, A.F.I. Adbou, Z. Shaheen, R. El Feky, Z.A. Gheit, A.K. Said, 0. Galal, G.G. Harrison & A. Kirksey

The Amazon Basin Food Project: An Integrated Approach J.F. Kientz

Discussant: J. Caldwell

ANIMAL-CROP INTERACTION — Room 207
Presiding: L. Harbers

Complementary Nature of Crop/Animal Research
J.K. Ward & M. de Garcia

WEDNESDAY, OCTOBER 8

The Crucial Role of Various Aspects of Agricultural Mechanization in Farming Systems Research and Extension R.N. Kaul

On-Farm Trials in the Evaluation of a Composite Technology: The Case of Alley Farming in Southern Nigeria A.N. Atta-Krah & P.A. Francis

12:00- 1:30 pm Lunch Main Ballroom

Symposium Evaluation

1:30- 3:30 pm METHODOLOGIES FOR ADDRESSING CROP/ LIVESTOCK INTERACTION Little Theatre

Presiding: J. Flora

Livestock Technology Validation and Transfer: A Case Study M.W. Sands & L.A. Hertentains

Crop/Livestock Systems Research in Asia: Design and Testing OFR A.D. Calub, D.B. Roxas & V.R. Carangal

Research Methodologies for Conducting On-Farm Livestock Research M.A. Kujawa & J. Oxley

Networking as a Methodology for Addressing the Crop-Livestock Interaction: The West African Integrated Livestock Network as an Example S. Poates

Closing Comments
Discussants: Zandstra & Lightfoot

The Farming Systems Support Project will conduct its annual meeting following the Symposium beginning at 4:00 pm October 8, all day October 9 and finishing at noon on October 10.

Farming Systems Research and Extension:
Food and Feed

Edited by Cornelia Butler Flora and Martha Tomecek

STRENGTHS, WEAKNESSES AND POSSIBILITIES OF AN FSR/E APPROACH

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Second Generation Approaches

to Farming Systems Research and Extension

by George H. Axinn*

Farming Systems Research and Extension efforts have been significant for over a decade. Excellent work has been done by teams of agricultural scientists, sometimes with economists and other social scientists. The purpose of this paper, recognizing the achievement by those who have used the FSR/E approach, is to suggest that the time has come to re-assess the first generation approaches, and evolve into a second generation.

Scholars in institutions within the United States were not alone in their concern with FSR/E. The international agricultural research centers have been leaders in this work, as have been such agencies as the Food and Agriculture Organization of the United Nations and the World Bank Group. Several U. S. Universities have made significant contributions in developing a network of people with interests and experience. This networking, involving the University of Florida and Kansas State University and others is among the achievements. (1) FAO has developed and promoted similar approaches, in several other countries. (2)

But the early blush of enthusiasm for FSR/E resembled that of other fashionable ideas. It was picked up by USAID and other international development assistance agencies and heavily funded. But it may not have lasting power. Typically, such appropriate and timely strategic concepts become associated with unrealistically high expectations.

In the short run, the FSR/E approach was expected to develop and deliver useful, practical agricultural technology appropriate to the small farm families of Africa, Asia, and Latin America. And this was to be accomplished through national government organizations which had generally not addressed those goals.

THE RATIONALE FOR FSR/E

By the early 1970s, the international development assistance world had become well aware of two different needs which provided the underlying rationnale for FSR/E. The first great need was for technology from the agricultural research organizations which fit small mixed farm family ecosystems. Many of the agricultural extension organizations which had been developed in ministries of agriculture were failing to deliver, as viewed from the perspective of either increases in food production or improvements in rural life for the majority of people. These agricultural extension systems generally
did not include a vital role for organizations of local people.

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Instead, they took the form of "delivery systems," designed to deliver "superior" technology from the center out to rural people who would somehow benefit from it. (3)

That type of extension system is absolutely dependent upon an agricultural research organization which generates or borrows the necessary and appropriate technology. Therefore, one of the great needs which had become apparent was for an agenda for agricultural research which would be more relevant to the small mixed labor— intensive farming systems on which most rural families live in Africa, Asia, and Latin America.

The second need was for more effective coordination of operations among government organizations intervening in agriculture. It is not normal to find communication or cooperation, much less coordination, among branches of governments concerned with agricultural credit; supply of such inputs as seed, fertilizer, and irrigation water; marketing of outputs beyond the farm; agricultural extension; or agricultural research. More critical, there tends to be little coordination among professionals concerned with livestock, cereal grains, fruits, vegetables, and farm management within ministries of agriculture. Somehow it was hoped that FSR/E, with its comprehensive view of the farm as a system, would help meet this need.

The record of achievement with respect to both of these needs has not been impressive.

Why is that?

Some observations of the "first generation" of FSR/E may be explanatory.

THE CONSEQUENCE OF OVER-SPECIALIZATION

The International Agricultural Research Centers were ahead of USAID in their enthusiasm for farming systems approaches. By the late 1970s several of them were supporting farming systems programs. But it was difficult to overcome their own mandates to one crop, or to a few farm enterprises. With a staff and an administrative structure geared to rice, or to maize and wheat, there naturally evolved such phenomena as "cropping systems research and extension," "rice-based cropping systems research," and "maize in the cropping system" work.

Moving to considerations, for example, of the use of fodder produced as part of the maize plant in a livestock system, tended to be beyond the ken of the professional agriculturalists and their organizations.

We professionals tend to be different from members of the farm family. They are forced by circumstance to consider the whole farming system. We professionals are so well disciplined in our own increasingly specialized disciplines, that it is difficult for most of us to consider the complex farm as a system of such components as

plants, livestock, people, soil, climate, etc. Moreover, the basic organizational and financial mandates encourage a more narrow focus. Even though dedicated committees struggled seriously to comprehend the whole farming system, they tended to settle for less.

This may have been related to strong emphasis on the "farming" part of farming systems, and little or no attention to the "systems," part. Few, If any, systems analysts were part of the FSR/E teams. Mostly, the teams were agronomists, soil scientists, and perhaps agricultural economists. Although, as Cernea (4) has pointed out, anthropologists and rural socialists had a crucial role to play. But the point Is that the application of systems science to the whole system, was not a high priority during the "first generation."

The effort did move some of the work away from the research farm to the farmer's field. And It did achieve more attention to what would actually work on the farm. But It tended to be basically aimed at adapting the technologies developed at the International Centers to the farms of "target" countries. There was little opportunity to take a problem-solving approach to whole farms as systems.

The Food and Agriculture Organization of the United Nations has also been trying. There, as In some U.S. Land Grant Universities, the farm management approach tended to dominate the farming systems work. Traditional farm management economists have worked with different types of farming systems, even constructing typologies, and aiding extension personnel with a view of the whole farm. But they tended to look at farms as business systems, rather than as farming systems. Thus many relevant aspects were neglected. These sometimes included such phenomena as: consumption within the farm family, productive work within the farm household but not 1n agriculture, productive work outside the farm household, human Interactions which were not merely "labor," sustainable agricultural practices, linkages and relationships between the farm family ecosystem and Its near environment, and linkages between the farming system and components of the larger soc1al-econom1c-pollt1cal-cultural system of which 1t 1s a part.

PROBLEMS OF THE TEAM APPROACH

Looking back over the last decade, while the attention to farmers' fields has been a plus, the assumption that FSR/E requires group collaboration among many different specialists 1n the traditional agricultural sciences may have been a minus. It has required time and money to "train" such teams of specialists to know each other, to trust each other, to respect each other's professional skills and competence, and then to be able to fit their various disciplines together.

Since individuals from different disciplines tend to have different value systems, as well as different professional languages, collaboration 1n depth has been a rare phenomenon. From what I have personally observed In Nepal, and from what the literature reveals 1n other countries, the costs have been relatively high, and the benefits have been relatively low.

BIT OF ARROGANCE

Another problem during this so-called "first generation" has been a little bit of arrogance. The arrogance 1s not Intrinsic to farming systems work. Quite the contrary, to approach agricultural research and extension from a farming system perspective 1s basically a humble approach. In fact, the genius of the farming systems approach 1s that very humility, which should definitely be preserved 1n the next generation.

But the promise, or at least the expectation among financial support providers, that FSR/E teams could come up with recommendations to farmers 1n a relatively short time; and that these recommendations would encompass better technological/economic packages than farmers al ready had — that was a bit arrogant! If 1t were that slmpl e, farm families and their national agricultural research agencies would have done 1t long ago.

The second generation probably needs even more humility. This suggests more attention to first-rate description of farming systems, Including all the nuances of the mixture of the various components within Its ecological n1che.(5) Such description 1n depth, as anthropologists have demonstrated for several decades, provides an excellent base for further problem-solving research. If the biological and economic aspects of descriptive research can be supplemented with the social, cultural, and political, then the second generation will have significantly greater delivery power than the first.

Not that description alone 1s adequate. It certainly 1s not. But quality description 1s probably a necessary precursor to the type of farming systems research which will lead to the promised Improved technical/economic modifications. A principle of action might be: "description before prescription!"

THE POLITICS OF AGRICULTURAL RESEARCH

Finally, while diagnostics are an Important part of FSR/E, I believe there are also diagnostic probl ems 1n the rationale of the approach. Why was 1t that agricultural research organizations 1n most countries had not developed technologies which contributed significantly to the well being and productivity of the small mixed farming systems? The research systems did very well 1n enhancing large-scale, mono-crop specialized, commercial, market-oriented agriculture. That has been their greatest achievement, and for that they deserve considerable credit.

The hope for FSR/E was that 1t would either convert the agricultural research establishment Into doing work that would be useful to small farmers, or that new organizations would be built around FSR/E to do that type of research. But the strategy did not work. Probably that was because there are very good reasons why the

present agricultural research systems have the types of agenda they have. It Is not merely a matter of no one having thought of FSR/E 1n the past.

Rather* the agendas of agricultural research organizations have historically been derived 1n accordance with the needs and Interests of those who control the organizations. That would be normal for any organization. And the historical evidence 1s compelling In this Instance, as Butte! (6) has pointed out. From the great research Institutions 1n India and Indonesia, geared to production of export crops for colonial powers, to the early experiment stations of the American Northeast, geared to their State Horticultural Societies, "who pays the piper calls the tune."

The agricultural research organizations have a good record of performance from this perspective. They were fairly successful 1n developing appropriate technologies for producing cocoa and oil palms 1n West Africa, cotton 1n South Asia, and coconuts and fruits 1n South East Asia. They also produced bananas 1n Central America and South America. Where farmers' organizations or agricultural societies controlled agricultural research organizations, as In parts of Europe and parts of the U.S.A., they produced technologies which made life better for the members of those organizations.

The former colonial world 1s plagued with agricultural research organizations which have found 1t very difficult to convert to studies of food crop production for their own areas, or other problem-solving research focused on the needs and Interests of local farm families. They had become Institutionalized 1n a different mode. So had the agricultural extension organizations. A significant change 1n their programs would require change 1n their basic doctrine, their organizational structure, their leadership, and to some extent 1n their professional scientific staff. Therefore, It would have been unrealistic to expect that merely by providing a little foreign technical assistance 1n FSR/E they might be likely to achieve the ambitious goals which the International development assistance community had for them.

A possible solution to this problem, at Its root, would be to further decentralize control of the agricultural research organizations. This would have to be done separately within each nation state, but 1t could be done. Such decentralization, from my perspective, 1s the most critical variable governing the agenda for agricultural research and extension organizations. It could have benefits for small mixed farming systems wherever they are found, Including within several of the states of the U.S.A. Unfortunately, decentralization seems to be neglected by those concerned with Improving the management of the agricultural research establishments.

From this perspective, 1t seems to me that significant achievements 1n 11 ne with the goals of FSR/E are not likely without more attention to the administration, the politics, and the

international diplomacy of the agricultural research organizations. Changing their agendas may only be feasible with change in the ways in which they are controlled.

BRIGHT FUTURE

But the basic idea of "farming systems" is attractive to many, and may be necessary for the bright future to which we aspire!

It is attractive to some agricultural researchers, but not to all. It is attractive to the international development banks and to the international development assistance agencies because it fits their present commitment to the poorest of the poor — the smal1 mixed farm family ecosystems — the rural majority. And it is attractive to many professionals who are seriously concerned about those who till the soil and tend the livestock on those same small farming systems.

It is also attractive to colleges of agriculture, both in the U.S.A. and abroad. This relates to the changing population of agricultural students and faculty in the last three decades, making them more like those of other parts of the world than they were during the first one hundred years of the "Land-Grant" system. We now have the phenomenon of professional agriculturists who are specialized scientists with little understanding or appreciation of the practice of farming. Increasingly, like in most other countries, neither students nor teachers of agriculture ever had much contact with farming, and thus tend to depreciate the skills, knowledge, and competence of farmers.

This attractiveness points to the need for a second generation of farming systems work. Now the question becomes, what should be the nature of that second generation? Which aspects of the first generation should be preserved? And which new dimensions should be created for the next generation?

For the future, I should like to suggest three strategies.

FARM FAMILY PARTICIPATION

First, as so many of those who have tried to do FSR/E among the rural people of remote villages in Africa, Asia, and Latin America have discovered, the farm family itself has been doing farming systems work for a long time. Forced to cope with the whole system, farming families have had the harsh choice of learning how to survive in their ecological niche or migrating away. Each generation has faced the new problems brought on by changing weather patterns, alternative cropping or livestock availabilities, shifts in soil and water availability, new insect or disease pests, or changes in potential market. And each generation has studied its alternatives, and made its decisions.

No, they may not have been literate. There may not have been any literature review. There were no research grants or publications,

either. But these rural people have been doing farming systems research for generations. If it were not for that research, most of modern agriculture would be unknown.

In the same spirit as our best FSR/E during the last several years, farm family members should increasingly be full partners with the professional agricultural research community. Farming Systems research could well evolve strategic approaches through which farming people have greater influence on what types of problems are studied, and on the criteria for evaluating alternative technologies. I see that as one priority for the second generation of FSR/E.

HIGH QUALITY SYSTEMS DESCRIPTION

My second strategic suggestion is a shift from emphasis on the quick delivery of results to more emphasis on better quality of description. It could be assumed that a separate and highy respectable task is to describe and understand a farming system. The same applies to typologies of farming systems. In the first generation, there may have been too much attention to the word "farming" and not enough to the word "systems." Very few of the teams had systems analysts or systems scientists as members. More use of such professionals might well characterize the second generation.

Perhaps our highly differentiated and specialized systems of technical agricultural education have room for training some "farming systems generalists?" These professionals might work like Family Practice Specialists among other specialists in human medicine. Their conceptual frameworks and their field operational skills would fit them for the tasks of making quality descriptions of whole farming systems, and then of calling on appropriate specialists for the diagnostics. One way to move in this direction would be to offer a masters degree program in farming systems. A first step would be to develop more course work in farming systems, both at undergraduate and post-graduate levels. Both of these would require time, and call for slow and careful beginnings, as a new professional specialization emerges. But I believe there is now a market for such persons, both in the international organizations and in the Cooperative Extension Service of the U.S.A.

DECENTRALIZATION OF CONTROL

And my third strategic suggestion is really a combination of the first two. To take advantage of the wisdom of farm families, and to utilize farming systems generalists, there is need for decentralization of control of the organizational structure and the agenda of agricultural research agencies. The implications of this are that agricultural research organizations and their branch farms (or experiment stations) would be forced to address the problems of farm families in their immediate vicinities. If representatives of those families had a strong voice in selection, placement, and rewards for the technical and scientific staffs of the research farms, those individuals would be more likely to be influenced by the needs and

interests of farm people in deciding what to study. And if program and project review at the research stations also included suggestions and opinions from such local people, the research agenda would be more relevant. These two steps may not be sufficient to change the whole system in the direction of relevance to the small, mixed farming systems of their areas, but they are probably a necessary beginning.

And these three strategies are equally promising for domestic and overseas agricultural research management. In fact, more domestic farming systems research would help legitimize the involvement of North Americans in this work in Africa, Asia, and Latin America.

TRANSCEND THE DISCIPLINARY WALLS

The name of FSR/E is another matter. We may need a second generation name. Immediate funding from traditional sources is also a problem. We may need to explore alternative financial arrangements. But I am optimistic that if we develop a second generation approach which builds upon the experience and the successes of the first generation, and adds appropriate new features as we discover them, the future for a sensitive, holistic approach to farming systems research and extension is bright! Our greatest task will be to transcend the disciplinary walls, see the farms as farm families see them, and apply our science, our skills, and our creativity!

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FARMING SYSTEMS RESEARCH AND EXTENSION IN THE WORLD SYSTEM CONTEXT

Herbert F. Lionberger*

So What?

We must understand how FSR/E fits and operates in the world system for agricultural research and development of which it is a part. Otherwise, it like so many social experiments, may well be evaluated in terms of the wrong criteria and be found wanting (Kellogg 1983). When we understand how it fits in we can:

1) evaluate it in terms of what it is capable of doing,

2) avoid unnecessary mistakes and unrealistic expectations,

3) improve its potential for improving the lives of many small farmers who have been by-passed by the information and technology explosion and

4) better assess the role that subject matter specialists can play in FSR/E

Properly seen as a unique new interface between information generators and information use it 1) can enormously facilitate the transformation of research knowledge into useful farm practice and 2) strengthen existing research-extension systems upon which it must continue to draw for information and support.

The Natural Process of Information Generation, Dissemination and Use

Whether we depend on specialized systems to produce new information and technology for us, as we do now, or rely on individuals, as we did in the past, the sequence of "what kind of people get involved in doing what, in what order, over time" seems to be much the same. The usual sequence has occurred so frequently that (McDemott 1971) has referred to it as a natural process. It goes something like this:

1. Investigators concerned only with extending the frontiers of knowledge, e.g., what is light, matter, heat, electricity, space, and the like.

   They typically have little interest in producing something useful.

2. Other investigators who try to intervene in these phenomena e.g. bending light rays, containing electricity, controlling its

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flow, etc., mostly just to see if it could be done.

But still they are not much interested in making anything useful.

3. Inventors who put bits and pieces of information and technology together into something useful for fun, pleasure or actual use just to see if it can be done, e.g. voice boxes (radios), taking machines, etc.

4. Developers, who see a chance to benefit from its use, mass produce and sell it.

Intrepeneurs, we call them.

5. Distributors who specialize in getting the new information services or product in the hands of potential users.

Sales departments, extension services and the like.

6. We the general public who use the innovation, (i.e., victims, or benefactors as the case may be).

Use of Specialized Systems to Invent and Deliver — The New Way

In the early days of individual invention this theory-to-practice sequence normally occurred over many years, (maybe several hundred), in an almost wholly chance manner. Also most of what was invented got lost. One anthropologist put the figure at 99 percent (Linton 1936).

Under the new system, steps one through four and sometimes five also were incorporated into a single system. The net result has been that:

1. The whole theory-to-practice process is:
   a. greatly speeded up and was
   b. for the first time put under the control of man

2. Virtually no invention or information of value gets lost

3. New information and technology has accumulated enormously, often at a geometric rate

4. Rapid social change is assured.

Functions That Must Be Performed To Make The Systems Work (in the intended research, develop, and deliver manner)

Since these systems seem to have emerged for the first time in our "so called" land grant universities and since their experience is well documented, the functions that must be performed to make the theory-to-practice sequence work can be identified (Kellogg and Knap 1966, Edmund 1978). These and their historical antecedents are:

- Innovation - development of new information and technology.

This was added to the land grant university teaching mandate because there was too little to teach.

° Adaptive testing - Testing of new information and technology in actual situations where it will be used to see if it will work and making adjustments until it does.

It has been specified as kind of an after thought because too many inappropriate technologies have been delivered to the consuming public with questionable results.

° Dissemination - getting the locally adapted new information and technology out to users.

It was first added to the land grant university charge because unused research findings were accumulating in the files of researchers.

Even now one distinguished scholar says in essence if you think research information will get out and be used without such a service, forget it. It hasn't happened yet (Havelock 1971).

° Information - informing people about the field tested new information and technologies, (What they are, what they will do, how to use them, etc.

It is a sub-function of the dissemination function—identified from diffusion research (Rogers 1983, Lionberger and Gwin 1982).

° Persuasion - convincing people to use the new innovations —
another finding from diffusion research that shows that information and persuasion are conceptually different and that the requirements that fanners impose for each are different.

° Integration - fitting the new information and/or technology into the users own farming system to achieve his own ends.

Anthropologists have long reminded us of this greatly neglected and often very difficult requirement (Linton 1936).

° Confirmation - giving adopters reasons for continuing to do what they have recently started to do so they won't quit for the wrong reason.

A late finding from "diffusion research" but mostly a product of research findings from advertisers.

These then are functions that must be performed to make the research, develop and deliver sequence result in sustained use of the product (information, or service) delivered. There are options for "by whom" and "how" each can be done; also for the organizational arrangements for achieving them. But there are none that permits omission of any one of them. This functional sequence is diagramatically represented across the top of Figure 1.

Although these 7 functions complete the theory-to-practice (research, develop and deliver) continuum we must add another, namely, governance. With all but integration and confirmation incorporated into a single functionally connected organization as in the U.S. agricultural research-extension systems, decisions must be made on how, by and for whom the system will operate. When

left to insiders they are likely to run it mostly for themselves, i.e. researchers for their own colleagues and extensionists mostly for theirs. But, when there is heavy client input, as in our land grant universities, the agricultural research-extension system in Taiwan (Lionberger and Chang 1981) or in the new agricultural universities in India (Nagel 1979), professionals defer to the interests and needs of the people. If the system has adequate resources—and still fails to deliver on their behalf as it should—it is the people who run it, not the system that is at fault. This is a governance function problem.

The way system responsibilities tend to be divided up is represented by the solid-lined circles in the diagram. The necessary on-going communication among the subsystems is reprinted by the arrowed lines between and across these circles. A horizontal line labeled governance across the entire functional sequence indicates that some direction of the entire system is necessary. The dotted line circle indicates a nearly universal need for an additional joint in-field problem solving information generating capacity much like FSR/E. This part of the system can best be visualized by thinking of the FSR/E Figure 2 overlaying Figure 1.

There Are Also Other Necessary But Almost Hidden System Features

Failure to see and understand them results in a badly distorted view of what a system is like and what it can do. With a research, develop and deliver history such as that of our land grant universities, a tendency to view them from top down and an inclination to overlook the obscure egalitarian features, it is little wonder that they have come to be seen mostly as top down research, develop and deliver entities, and extension as "straight line" banker type education. But when they are taken into account these charges are not valid. The more salient of these are the:

1) People service norms by which they ideally and generally do operate, (Lionberger 1986)

2) Mandatory involvement of the people to be served in the governance of their research and extension programs and

3) Elaborate interpersonal network that forms among researchers information specialists and ultimate users (Lionberger and Chang 1982).

Unfortunately these features usually have been left behind when these people service universities have been tried in new places.

There is also an inclination to overlook a new research—use interface much like FSR/E that had to be added to the initial RD&D capability to deal with problems where:

1. The research based knowledge is either not suited for direct local use or simply is not available,

2. Professionals with potentially useful information don't understand the local

3. People with problems don't know what the professionals have to offer and don't trust them and,

4. Careful adaptive testing of specialty information and/or local generation of new information is needed.

At the University of Missouri this new interface between research knowledge and use is known by the kind of problems it addresses, namely rural (community) development (Lionberger and Wong 1983). In the Central American agricultural setting it has been referred to as participatory research and development (Whyte 1980). More recently it is coming to be known as farming systems research and extension (Shaner, Philipp and Schmehl, 1982).

Both RD&D And FRS/E Are Needed

Since there is a continuing need for both RD&D and FSR/E the last must always be thought of in the context of a world wide research-extension system upon which it must draw for its professional manpower and much of the information that FSR/E needs (Butler 1983). The larger world system continues to operate in mostly a research, develop and deliver manner.

World agriculture is serviced by our land grant type universities, 100s of government directed research stations and, the international research centers. Personnel exchange occurs among them and there is an elaborate communication systems that operate within and across them. With the aggregate of resources allocated to them and the within country extension services attached to the state and local research centers[1] there is no science theory-to-practice (research develop and deliver) operation that anywhere near equals that devoted to world agriculture.

Although land grant universities address all activities from basic research to in-field use in a single integrated operation (steps 1 through 5 on page 2), this is not necessary for countries to fully benefit from the world wide-agricultural research network. In fact a country can get much more for its money by concentrating on what has to be done at home, as for example the Taiwanese have done (Lionberger and Chang, 1970 and 1981).

Findings from basic research done any place can be used anywhere in the world. Within country cultural differences have no influence except on what local nationals choose to do with it. But all functions beyond innovation in the theory to practice continuum (adaptive testing, dissemination and the attendant information, persuasion, integration and reinforcement functions have to be done at home. Fortunately they are less expensive to do, less chancy, and offer the quickest pay off. Also they can be done with less highly trained manpower.

Bridging the Research Knowledge - Use Gap

Requirements. This is the point at which a blending of research extension and use is necessary. Innovations generated by whatever means must be field tested and, adapted to local conditions. Simultaneous attention to all informational requirements that farmers impose for arriving at adoption-use decisions can greatly facilitate acceptance. These include:

1) Informing farmers about the innovations (the information function)

2) Persuading potential users to use them (the persuasion function)

3) Fitting the innovation into the farmers own farming system to achieve their own ends (the integration function)

For adaptive testing and all of these, respect for and use of indigenous knowledge is an absolute must. This requires close sustained interaction with potential users. Also the final judgement about the ultimate utility of what is developed must rest primarily with the users themselves. Outsiders who would help must be capable of doing so in the context of what local people want to do and the way they want to do it. As a minimum this[2] requires a thorough understanding of and appreciation of the farmers situation.

Innovations must be presented by communicators who:

1) meet local credibility and knowledgeability requirements and

2) cater to what farmers require in arriving at their adoption decisions. At this juncture where informing and persuading farmers are at issue trusted peers and what they have learned from experience are very much in demand.

Also after adaptive testing has made an innovation as locally adapted as local research can make it, after farmers have been persuaded, and after they have decided to use it, they still must fit it into their own farming systems. This always requires more changes, mostly in what farmers do and, how they do it, but often also in the innovation itself. Sometimes these changes are substantial as in the change from open pollinated to hybrid maize. (The integration function). Outsiders who do not thoroughly understand an individual's farming system and what he or she wants to achieve can't be of much help. Here again trusted peers who have successfully used an innovation are likely to be most helpful.

Two jointly operated options for blending research knowledge and practical experience at this juncture in the research, develop and deliver process have worked very well; one used in Taiwan that doesn't have a name-the other FSR/E.

The Taiwan Farm Improvement Station Centered Option Adaptive testing and simultaneous attention to the decisional requirements imposed by farmers (information, persuasion and integration) is done in strategically located field stations concerned with farming as farmers locally do it. (Lionberger & Chang 1970, 1981). These centers, very appropriately named district agricultural improvement stations, are very different from their in-country research institutes that specialize in single crops. Their main objective is to adapt innovations from whatever sources to local farming conditions. The officers in charge do both research and extension work but think of themselves as neither. These farm reared grade or high schoolers are known as agricultural technicians. In cooperation with township farm advisers and local farmers they help local farmers try potentially useful innovations in their own fields. What works by their standards is recommended to other farmers in the area with similar kinds of farming systems. What doesn't is worked over, tried again or discarded as farmers choose.

The information generated becomes the subject matter for frequent farm adviser short courses held at these centers. The farm reared grade school educated advisers who attend enjoy high credibility among farmers and are highly sought by them for both information and advice (persuasion) (Lionberger and Chang, 1968).

Although the Taiwan system closely approximate the ideal for adaptive testing and simultaneous performance of information, persuasion and integration functions, it requires the establishment of field stations in typical farming areas. This Swisher (1983) notes may be too costly for limited resource countries. Nevertheless they demonstrate very well the utility of a functionally undifferentiated research-extension user interfaces between research knowledge and use; also of farmer participation for adaptive testing and facilitating the use of locally adapted innovations—thus the blending of unattended gap between research and extension (Bemis, 1985, McDermott, 1983).

The FSR/E Option FSR/E the second option also provides a blended functionally undifferentiated interface between research and farm experience in which information specialists, extension workers and farmers participate in an egalitarian interchange to collectively

1) assess local situations,

2) propose options,

3) consider alternatives,

4) test some locally and ultimately

5) judge their utility for continued local use.

FSR/E provides an excellent, highly adaptable, mechanism for integrating specialty information into local farming systems, enhancing legitimacy in the eyes of farmers, and the production of a product that can be easily integrated into what farmers do. In a sense it formalizes what farmers have done for centuries to solve their problems, but in this case with outside help.

It has the most to offer where

1) locally adapted science based information is in short supply,

2) what information is available needs adaptating to local farming conditions, and

3) some of it needs to be generated locally.

It, like the Taiwan system, is basically an innovative new interface between research and indigenous knowledge and not a new model destined to replace existing research-extension systems.

As a mechanism for adaptive testing and simultaneous performance of other necessary adoption related functions, it too approaches the ideal. Requirements that farmers impose for achieving these functions are closely approximated in a setting where outside informational inputs are introduced, considered and used as deemed appropriate. The utility of the innovations

tested is judged mainly in terms of farmer standards and the credibility of the originating source is greatly enhanced. This in turn facilitates performance of the information and persuasion functions. Because in-field testing is done in the context of locally prevailing farming systems integration problems are simultaneously addressed. This tends to minimize the final adaptations that a farmer must make to use it.

Maximizing the potential of the team effort is highly contingent on facilitating inputs from participants (researchers, extensionists and farmers). This is mainly a communication problem.

Since FSR/E is a kind of social technology, new to the agricultural scene qualities of comparative utility, compatibility, and local adaptability apply to its introduction into new settings just as it applies in presenting new technologies to farmers (Rogers 1983, Lionberger & Gwin 1982).[3]

The utility of FSR/E is high for meeting situation assessment and adaptive testing needs. No new extension or research stations are required. On-board researchers and extension workers can be trained to assume the new FSR/E duties. When not working on FSR/E teams they can revert back to their more conventional assignments where most must continue to work. Farmers who help serve can spend more time farming and all presumably will have benefitted for having participated. When institutionalized as a new research-user interface with existing within country research-extension systems, as it must be, benefits from the larger within-country and world-wide research-extension systems can be enhanced (Butler 1983).

It is entirely compatible with the existing research, develop and deliver systems as they exist in most countries. It is really an improving invention that can make the old systems work better. As such it is not a threat to their continued existence. In at least one agricultural research-extension setting it is coming to be regarded as the ideal way to use university based information in the service of people generally (Holik, 1986).

In a more general sense FSR/E represents a kind of a problem solving invention that is becoming increasingly institutionalized as part of societies arganized effort to put specialized expertise to use in the service of people.

Prospects for immediate benefits from resource inputs into FSR/E efforts are much greater than into RD&D and given proper diffusion of findings from local projects to other farmers it is less costly. For effectively performing the adaptive testing function and maximizing benefits from the existing research knowledge base it is probably the best alternative yet.

But FSR/E can be costly in terms of number of people reached unless results are disseminated to and used by other farmers to improve their living conditions. This, is probably how it will be ultimately evaluated (Kellog 1983). Although there is no reason to believe that substantial diffusion will occur in the absence of a specialized effort to get it disseminated and used (Havelock 1971), the extending part of FSR/E seems to have been neglected. This is seen in the exclusion of extension specialists from FSR/E teams and extension of findings to other farmers (Compton 1983, Kellogg 1983).

Helping to correct these deficiencies are proper roles for communication specialists.

Maybe Figure 2 will help the reader visualize how FSR/E fits into and draws upon diverse informational sources to deal with problems of local farmers. In a sense it can be thought of as overlaying Figure 1 which represents the world research, develop and deliver informational system as it can operate on behalf of farmers everywhere. Models, as the one represented here are not necessarily true or false. They are always incomplete. This one deals only with information, generation and use. Support service systems and linkages that make FSR/E possible are not represented but must not be forgotten.

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Footnotes

1. This digression is not in defense of unfairly maligned land grant universities. Rather it is to direct attention to often neglected essential features of any RD&D system that persumes to operate in the interests of the public.

2. But for doing basic research—part of the innovation function-listening to farmers is not very important. The scientists' job is to extend the frontiers of basic science knowledge. Researchers of this type need mostly to communicate with each other-on a world wide basis if possible. They don't need to talk to anyone who has a problem that they hope researchers might solve. Even a lot of very good applied research can be done without close interaction with possible users.

Paradoxically however basic science researchers appear to be more productive of basic science research findings when they have to interact with researchers who have applied concerns (Pelz and Andrews, 1966).

3. It is only fair to note that the system of locally generating innovations and point-to-point dissemination in the People's Republic of China closely resembles many aspects of FSR/E (Sheridan 1981).

FUNCTIONS THAT MUST BE PERFORMED

THEORY-TO-PRACTICE ORDER OF ACTIVITIES (Kinds of People Doing What)

INNOVATION (Research and Development)

DISSEMINATION: Adaptive Testing, Information Persuasion (Adoption)

INTEGRATION: Reinforcement

GOVERNANCE

RESEARCH

1. Basic Researchers extend frontiers of knowledge

2. Applied researchers try to control the scientific processes

DEVELOP

3. Inventors develop something potentially useful

4. Someone tests it locally to see if it -

   - will work?
   - is feasible?
   - will fit it

   Adapts and retests as needed?

DELIVER

5. Linkers disseminate the information, product or service to potential users

6. Farmers put the locally adapted innovation to use

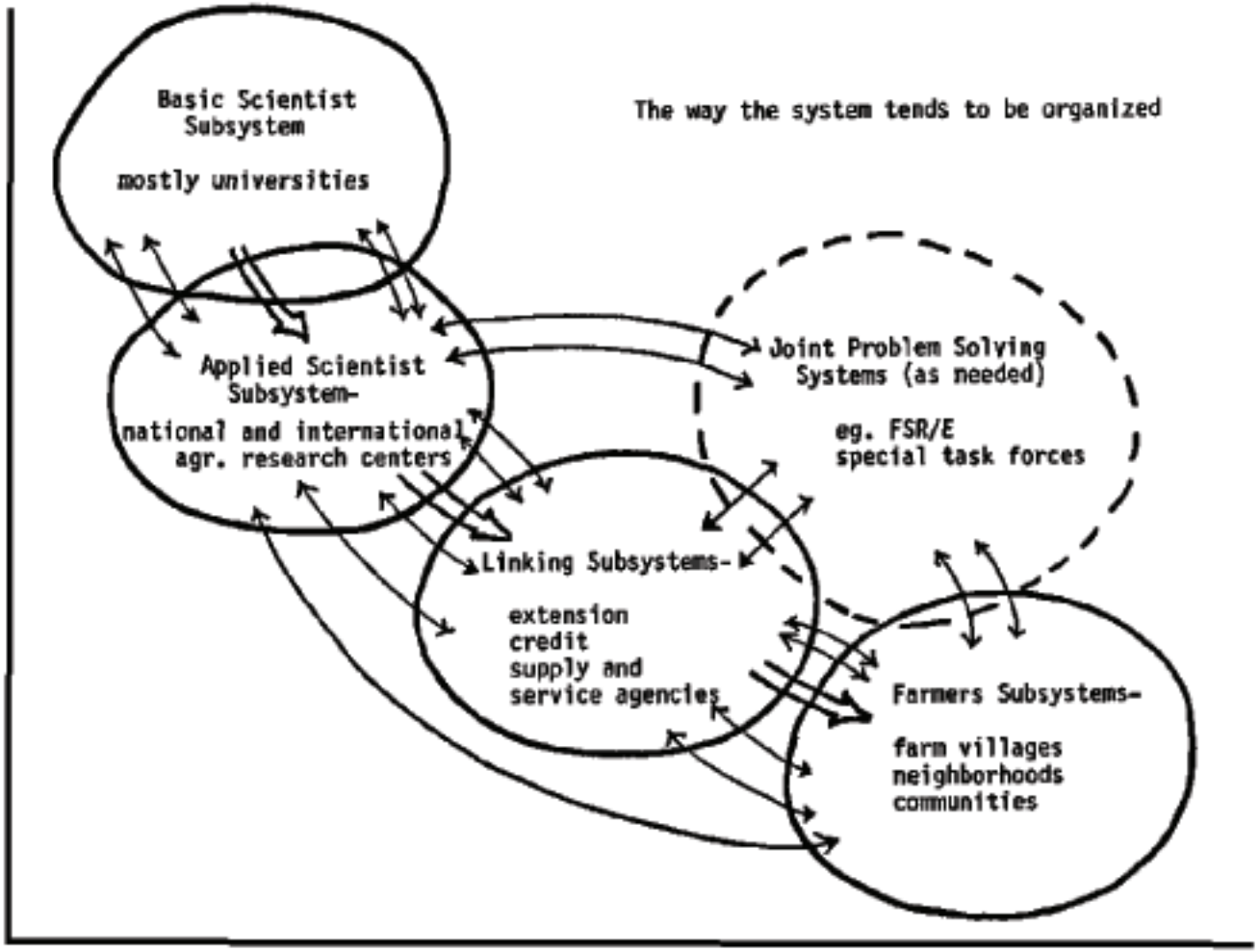

Figure 1. THE WORLD FARM INFORMATION SUPPLY SYSTEM

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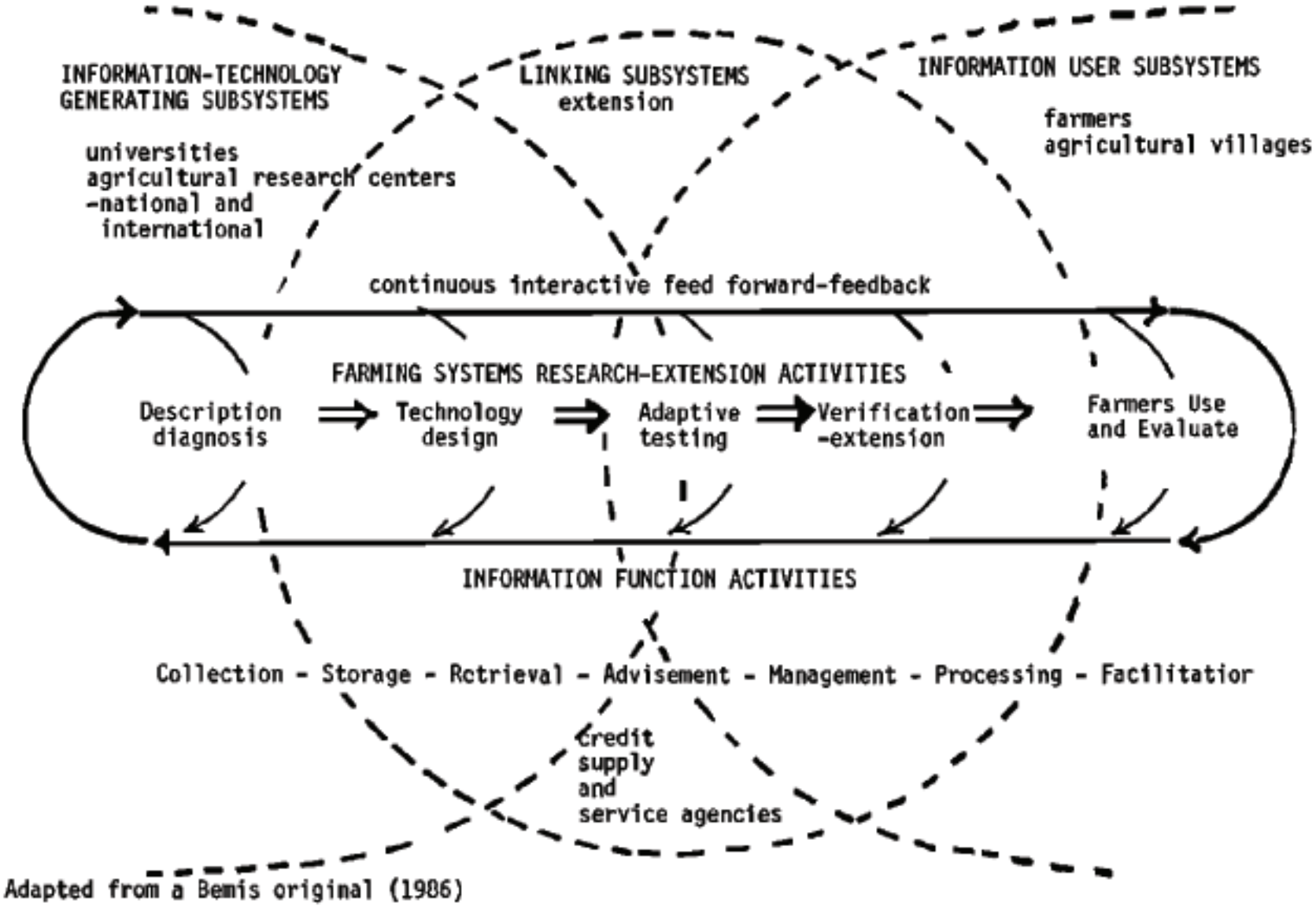

Adapted from a Bemis original (1986)

FIGURE 2. FSR/E IN THE LARGER FARM INFORMATION GENERATING-USE SYSTEM

Institution Building for Agricultural Production Systems Research in Developing Countries

by

Robert S. Temple*

1. Introduction

1.1 The use of the "Systems Research Approach" in agricultural research in developing countries has been promoted since the early 1970's mainly because scientists have felt that an integrated research approach combining several disciplines on a given problem would have quicker and greater "pay-offs" than conventional disciplinary research. There is no doubt that the integrated research carried out at CIMMYT in Mexico and IRRI in the Philippines had a tremendous impact on crop production throughout the developing countries. However, whether much of the so-called "systems research" really involved systems analysis is questionable. Many different definitions and approaches have been used under the blanket of such terms as: "the systems approach", inter-disciplinary research; multi-disciplinary research; farming systems research; on-farm research, etc. Regardless of these different approaches there has been progress in approaching production problems and deficiencies from several different angles and disciplines. But, credit must be given to strictly disciplinary research where one "bottleneck" is well known and its solution alone would increase production. There are many examples of the success of such research.

1.2 The research institutions in several developing countries have made the decision to incorporate "systems research" in their programs. Over the last ten years considerable confusion has arisen as to just how this should and could be done. The purpose of this paper is to draw to the attention of scientists working in systems research of the problems at the institutional level. Due to the experience of the author, most of the background information comes from livestock systems research and livestock-crop interaction research through projects in Bangladesh, Saudi Arabia, Sudan and at ILCA (The International Livestock Center for Africa, Addis Ababa, Ethiopia).

1.3 Some important clarifications on terminology need to be made at the start. Some lack of understanding has arisen among researchers, especially in developing countries, because terms have, oftentimes, not been well-defined.

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1.3.1 "On-Farm-Research" is not always "systems" research. Unless it is placed in the context of a "whole" farming system and the actual research being looked at and measured as a part of that system, it most likely is just field testing of a product, method, or a piece of new technology.

1.3.2 "Inter-disciplinary or multi-discipline" research is not necessarily "systems" research. Working on a single problem or constraint to agricultural production from two or more disciplinary angles without looking at the system as a whole and the interactions involved is nothing more than pure disciplinary research. In some cases, please understand, this in fact may be the best approach. However, in systems research the inter- or multi-disciplinary approach to a research problem is used in a systematic way so that all steps to solving the problem are identified and evaluated as part of a system. In the actual research, especially in the planning stage, flow charts, models and schematic drawings of "the" system under study are important.

2. Institutional problems in developing countries

2.1 Most developing countries lack the agricultural research necessary to solve their problems. This deficiency is due to several factors: a) lack of adequate facilities; b) shortage of local governments funding; c) shortage of adequately trained scientific personnel; and d) lack of the incentives necessary to keep the better scientists. In addition, the governmental and institutional framework necessary for sound research planning is not well organized. Research priorities are often established without sufficient information or data to be confident that the priorities are correct. The enthusiasm of a high government official for a particular research-development program is often-times the determining factor in setting research priorities rather than sound background data.

2.2 Research institutions in developing countries are usually organized along conventional disciplinary lines. Competition for funds from governmental sources and even from external assistance by the different departments is often fierce. Political pull by department heads many times determine who gets the funds rather than sound research priorities. Re-organization of agriculture ministries is a continual activity taking much time and financial resources away from badly needed research and development. It is readily agreed that in some cases re-organization is necessary but, again, the general case is that the "new" structure is determined by political pull or the personality dominance of a single prominent figure rather than sound background information needed to determine which structure is the most appropriate.

2.3 Infrastructure in terms of communication facilities, transportation, education, health, and access to basic rood and living requirements is notably lacking. Research

facilities are often established where the need for particular research is evident but where there is poor communication and transportation linkage and no hospital, educational facilities or adequate basic shopping establishments. Such conditions deter the top qualified scientists from taking positions in these more remote areas. If the infrastructural requirements are established in these areas, huge amounts of funds are required. The pay-off of such facilities is, sometimes, not, adequately determined before the building takes place.

3. Systems research involving livestock production

3.1 It is obvious from the foregoing that systems research has a place in developing countries research programs in setting priorities and solving the most important problems and eliminating constraints to production. Up until the mid-1960 's, most livestock research was conducted along disciplinary lines such as nutrition, animal breeding, and health. In most developing countries this is still the case. Technologies were developed by discipline with little concern as to how a particular innovation affected another input. Livestock systems research came about by looking at the interaction of one part of the system with another part. All of the factors affecting animal production became important - not just the traditional disciplines of animal research but also those of pasture and crop production, and the over-all impact of economic and social relationships involving the family, clan or tribe of the approach in the livestock field was pioneered at the International Livestock Center for Africa (ILCA) and has given a better understanding of where priorities of research should be placed.

3.2 The system involves the farmer, the land, the livestock, the family, the resources and the market for products. It becomes apparent that the goals of production are an over-riding influence on the system. The decisions reached in the production process are made on a trial and error basis with many factors influencing the system although in many cases these factors are not clearly defined in the farmers mind. Systems researchers are challenged to better define these factors and their interaction. Questions become apparent: What are the parts of the system? How are the parts inter-related and does a change in one part affect another? What are the main outputs of the system and is it of economic benefit to the farmer the socio-economic impact of the farmers decisions on the family, clan and nation?

3.3 The steps in livestock systems research can be summarized as follows:

1) Farm system analysis and problem identification

a) define the farming system, its production goals, and the motivation for having livestock;

b) determine the components of the system and evalutate their importance relative to one another;

c) establish priority of importance of the components;

d) determine the limiting factors in the existing system;

e) identify restraints and problems which can be removed through research;

f) determine from literature review and previous experience whether the problem has been researched elsewhere and if so test the solution to determine if it is applicable to local conditions.

2) Research programme formulation

a) if the solution is not already known formulate a research programme which should solve the problem;

b) formulate a research team of the appropriate desciplines to solve the problem.

3) Research. Conduct necessary research to obtain a solution or alternative solutions to the problem;

4) Testing

a) test the solution through systems modeling and determine cost and benefit to the farmer;

b) test appropriate solutions on "test farms" of selected farmers;

c) determine acceptability and economic benefit to the farmer;

d) determine if solution has "side effects" which affect the system as a whole;

5) Recommendation and training - linkage

a) recommend solution or innovation to the Agricultural Extension Service or Directoriate of Livestock Services which ever is appropriate;

b) determine whether training of extension personnel is necessary in order for them to train farmers to use the innovation;

6) Evaluation and monitoring

a) select areas and farms to evaluate the success of the innovation and whether problems are arising;

b) monitor the innovation to determine its success or failure.

3.4 A multi-disciplinary approach

3.4.1 From the above description of systems research it becomes obvious that there are several research disciplines required to study and improve the system. If livestock are part of a system and not a system themselves, understanding of the necessary. One of the most important concepts of systems research is that the disciplinary scientists working on a problem must be highly trained in their own discipline and that they do not work in isolation. They must be trained to interact with one another on a team. This is especially true in the phase of identifying the problems and restraints.

3.4.2 To study the farmer's systems and to identify the problems there has to be an "on farm" research team composed of the specialists which are deemed most necessary. If no work in the field has gone on before, a survey should be made by a multidisciplinary group. During the identification of the system, they would decide which discipline specialists should return on a routine basis to "monitor" the system to find out the restraints and problems.

3.4.3 From past experience, the disciplines which need to be included in the "on-farm" research teams vary from country to country, region to region (within country), and from agricultural system to agricultural system (within region and country). But in general, it would appear that since livestock are part of the larger agricultural or crop systems, the basic requirements would be in the fields of nutrition, forage and by-product utilization, food crops production and socio-economics (perhaps in the first stages, mostly sociology) with inputs and analyses from specialists in animal health, animal breeding, eonomics, poultry (of different disciplines), etc. In addition, a highly specialized "system modeling" group may be constituted to analyze the data and produce "models" of the system to determine where the significant problems and restraints appear to be. The "systems modeling" group has a vital input to the "on-farm" team in terms of the kinds of information and data which are necessary to collect.

4. Institutional structure involving systems research

4.1 Incorporating systems research methodology into ongoing institutions organized on disciplinary department lines has proven somewhat difficult. The philosophy of a multi-disciplinary problem oriented approach is generally greeted with enthusiasm but in practice there is generally a lack of understanding as to responsibility and the planning the network of research projects to accomplish the final objectives is usually absent. As outlined in the foregoing

section of this paper, the step involving farm system analysis and problem identification is difficult to organize on a multi-disciplinary basis. Although the organization of a multi-disciplinary team to analyze a "system" and to identify the bottlenecks to increasing production sounds great, there are very few cases where this has been accomplished successfully in developing countries. The reasons for this have already been pointed out: a) lack of facilities; b) lack of funding; c) lack of personnel; and d) lack of incentives. Few countries and institutions have the ability to organize such a systems analysis team which would have the primary responsibility of problem identification. Indeed, the traditional departments in an institution find it strange and difficult to "take orders" from such a group and even more difficult to reorganize their research programs. Some of the research projects which are being diligently worked on may prove to be of low priority in a developing country and other areas of research which are of high priority may be omitted from the over-all research program due to lack of the appropriate staff and funds.

4.2 Cooperation between different disciplinary departments is of absolute necessity in the "systems approach". In many developing countries, animal research may be under the control of one ministry while pasture and crop research is under a different ministry and economic and social research (if in existence at all) are under still a different ministry. Budgets are appropriated by ministry with little or no freedom for over-lap from ministry to ministry. If "systems research" is placed under a particular ministry, the other ministries which should be involved feel little or no responsibility to cooperate. If all of the appropriate disciplines are under one ministry, usually an arrangement can be made to establish a systems research team under the minister and separate from the other disciplinary departments. If it is established under a particular disciplinary department, cooperation with the systems team from other departments is usually less than satisfactory. Under any circumstance, the organization of a successful systems research program is fraught with some frustration, however, this is not to say that it should not be tried.

4.3 If trying the "systems approach" in one form or another does nothing more than alert the various disciplines as to the importance of other disciplines in solving problems, it has certainly had a positive effect. The effect may be less than hoped for but it may well bring about some cooperation and understanding that had not existed before. One comment which occasionally surfaces in this whole approach is that the systems analysis team is usually comprised of economists and computer specialists which have little understanding or appreciation for the "real" problems. The "systems team" should be composed of the various disciplines or at least have access to disciplinary specialists.

4.4 In the ideal situation, the systems team will become a permanent part of the whole agricultural research

organization. The composition of the team may well vary depending on the nature of the problems and constraints but it should continually analyze the problems, their economic relative importance to each other, and provide follow-up analyses as to whether the solutions have been successfully used by the farmers. This points out the importance of having the extension department involved in the systems approach. A continual appraisal of the farmer's situation and what is important to him or her is vital to the systems approach. A successful systems research program should not be considered a "one-time-shot". As new innovations are added into a farmer's system, the relative economic importance of the various components of the system will change and new problems and constraints will crop up.

INSTITUTIONALIZING FARMING SYSTEMS RESEARCH AND EXTENSION IN RWANDA'S BUBERUKA HIGHLANDS

E. Rawson*
R.Grosz**

INTRODUCTION

September 1986 marked the beginning of farming systems research and extension in Rwanda's North Central highlands. The Farming Systems Improvement Project (FSIP) was faced with a mandate to increase food production and to institutionalize farming systems research and extension in the project area. This paper briefly describes the steps the FSIP team has taken to link and mold researchers, extension agents and farmers into an expanded team to identify and solve production problems and improve family well-being. From project area entry to the establishment of the first 54 on-farm trials, the paper reports how the FSIP team kept farmers, extension staff and local authorities involved, so that they too "owned" a part of the problem and participated actively in finding and implementing the solutions. The paper further portrays the evolving drama of institutionalizing FSR/E in the existing research and extension systems without creating an artificial structure which would end with the termination of the project.

THE SETTING

Rwanda is a tiny landlocked country with an estimated area of 26,338 km^2 and a population of nearly six million people, 231 per square kilometer. The Farming Systems Improvement Project is located in Rwanda's North Central highlands where population density exceeds 500 persons per square kilometer. Population increases at over three percent per year.

Ninety-five percent of the population is engaged in farming. Until recently, food production has kept pace with population growth by bringing more land under cultivation. Current land shortages and declining soil fertility have now made it imperative to increase production per unit of land and to introduce fertility management and soil erosion control measures.

The project area is characterized by a series of sharply defined hills with steep slopes and flat ridges intersected by deep valleys with sometimes very large marshy plains at the bottoms. The altitude ranges from 1600 to 2650 meters with most of the land above 2000 meters. Area temperatures average 17°C with only slight daily fluctuation. They, however, vary considerably according to altitude. Annual rainfall ranges from 1100 to 1650 mm. with a bimodal distribution. There are three main soil associations. Altitude, temperature, soil and rainfall variations provide a number of micro-climates, which influence cropping and livestock systems significantly. The team estimates that there are at least nine microclimatic zones, based on altitude and soil association (Yamoah, 1985). Cropping systems which include 5 to 6 important crops and several crop associations further complicate farming systems research. (Paul and Bizimana, 1985)

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There are over 30,000 farm households in the project's four communes. The average family of five persons owns about one hectare of land. Their land holdings are fragmented due to the traditional system of inheritance, so most farms have small fields scattered at often great distances from the family "rugo" or dwelling. The dispersed settlement pattern of family units (the near absence of villages) and the fragmentation of land add to the complexity of farming systems research and the extension of appropriate interventions (Franzel et al, 1985).

The project area lies in the Ruhengeri Prefecture, one of Rwanda's ten administrative subdivisions. The prefecture consists of 16 communes, four of which were assigned to the project as its zone of action. Each commune is sub-divided into sectors and these in turn into cells as depicted in Table 1. These communes cover a land area of over 603 square kilometres.

Within the administrative structure the commune is the basic unit of development. The Communes' chief administrators are the bourgmestres. Bourgmestres with their councilors and heads of cells are responsible for agricultural development as well as for the political and social development of the community. These people along with the communal agricultural extension officers (agronomies) and agricultural monitors (monagris) represent the gate to the local community for conducting farming systems research and extension.

The agricultural extension system is linked to both the political administrative structure and to the Ministry of Agriculture as depicted in Figure 1. For the most part, the agronomies and monagris are involved in "extending" national agricultural policy "themes". The general flow of communications is from the ministry level to the prefectural agronome, from there to the sub-prefectural and communal agronomes and then to bourgmestres, sectoral councilors, monagris and cell officials. Finally the theme reaches progressive farmers and others (Grosz, 1985). In fact, the extension service serves to enforce the national will with the power to dispense and collect fines for infractions of national agricultural policy. This weakens the effectiveness of extension efforts and stifles communication from farmer to policy makers at the national level. National themes include erosion control, pit composting, use of manure and compost to maintain soil fertility, confinement of livestock, reforestation and family planning.

The extension service in the four communes is relatively understaffed. Its effectiveness is further hindered by the dispersed nature of the population.
Agents often walk. A few ride bicycles. As Table 2 shows, there are seven communal agronomies (technical agriculture school graduates) nearly two per commune and 25 monagri (little to no formal technical training). Each monagri is responsible for an average of two sectors. Given a population which now exceeds 175,000 persons and 5.2 persons per family, the ratio between families and monagris is approximately 1300 to 1.

The Institute for Scientific Agricultural Research (ISAR) is charged with principal responsibility for agricultural research in the country. The Institute historically conducted a research agenda which often lacked relevance to farmers' problems. It also lacked effective communication with the extension services and with the farmers who are expected to adopt "appropriate" technology generated by research. The impact of research on agricultural production despite 50 years of existence has not kept pace with Rwanda's needs

and expectations. Thus, the Government of Rwanda (GOR) considered the restructuring of ISAR essential, so that research would "truly serve stock-crop farmers by involving them, in some manner, in that research." (Nzamurambaho, 1983).

THE PROJECT AND ITS MISSION

In 1984 the Government of Rwanda requested USAID assistance in developing the FSR/E approach to strengthen ISAR's applied research capability and to effectively integrate all research and extension activities. Thus, in May 1985, the FSIP became a reality under a contract between USAID and the University of Arkansas. The FSIP was given a mandate to increase food production and to assist the GOR to institutionalize a farming systems approach to research and extension which included a mechanism for effectively linking research and extension institutions and their activities. To fulfill this mandate the project was committed to:

- build an effective FSR/E team
- develop and diffuse appropriate technologies to increase food production
- develop skills and understanding of Rwandan researchers and extension agents to conduct on-farm research and extension complete research studies
- develop data bases develop linkages with IARC's
- provide rural infrastructure to gain community support in the four communes.

The Rwandan Government pledged to compliment the process through the provision of:

- Rwandan researchers and mid-level technicians a Rwandan project director
- an appropriate work site
- a memorandum of understanding to establish formal relationships of the project (as a part of ISAR) with the local extension service (a part of MINAGRI)
- a coordinating committee to monitor project activities.

The GOR designated ISAR as the implementing agency for the FSIP project and ISAR's high altitude research station at Rwerere as the base of operations.

THE TEAM

The FSIP team at present consists of four foreign and two Rwandan researchers. The team still lacks two Rwandan researchers and seven mid-level technicians to bring the core team to full strength. Technical composition of the team is as follows:

- an agronomist
- a soil scientist
- a plant pathologist
- an extension trainer
- two agricultural economists, one the team leader

Thirty-five person months of short term technical assistance are included

in the contract to back the team to address problems for which the technical expertise is lacking.

SOME GUIDING PRINCIPLES

As a part of the team building process, the team hammered out the methodology which would be followed for entering the project area and for conducting farming systems research and extension. The following principles resulted from their discussions:

1. Diagnostics and on-farm research are key tools of farming systems research and extension. These tools provide a basis for making national research programs relevant to meet the basic needs of farmers. Extension provides the essential linkage between the researcher and the farmer. Appropriate extension not only extends "appropriate technology" but insures farmer involvement in the entire process, from problem diagnosis to participation in on-farm testing of plausible interventions.
2. An artificial or parallel system should not be created. Rather, on-farm research and extension should be conducted within the framework of the existing institutions. The question constantly before us has been, "What can we do which will remain when we leave?"
3. On-farm trials provide an important means of farmer and extension agent involvement and should begin as soon as possible.

THE STRATEGY

Following their September 1986 arrival, the team focused on establishing the first on-farm trials in "B" season (which started in March, 1986). All the necessary elements for meeting this goal such as team building, area entry, diagnostics, selection of interventions, farmer selection and planning experiments were adjusted in time and scope to meet this biological "window".

The team further insisted on interventions which addressed constraints farmers identified during the diagnostic surveys (Murekezi, 1986). For the initial on-farm research, the team chose bean trials to study disease resistance and sweet potato trials to study the adaptability of known shorter season sweet potato cultivars to high altitude conditions. Multi-locational trials would be used to study the life cycle of *Acraea acerata*, tent caterpillars which defoliate sweet potatoes. They would also be used to investigate mulch and alley cropping systems to address soil fertility and erosion control problems. Trials were to be simple in design and have a reasonable chance of success. The number of interventions would be few and the number of farmers limited in order to do well what we set out to do. We needed the opportunity to learn on the job without too high a cost. (Rawson et al, 1986)

The team quickly realized that they could not meet the deadlines with only the existing core staff. Implementing the area entry plan required close collaboration with the local extension system. Furthermore, selection of appropriate interventions depended on interaction with on-station researchers. We therefore decided to expand our concept of the FSR/E team to include both on-station researchers and local extension agents as depicted in Figure 2.

Through improved communications and involvement in research activities, we would strive to link farmer, researcher and extension agent as partners in an effective FSR/E team. Training would begin early. Those involved in this expanded team would need an awareness of the projects goals and objectives along with an understanding of FSR/E concepts and methods. Installing and monitoring on-farm trials would require improved technical skills.

ACTIVITIES BUILDING TOWARD AN EFFECTIVE FSR/E TEAM

Team Building

Part of the process of institutionalization involved "entering" the project area in a coordinated and positive manner. Planning together as a team how to enter the project area was strategic to project success. The FSR/E team needed to learn to work together. They needed to formulate common goals and objectives and an approach to the milieu. Methods and concepts of FSR/E needed refinement. They needed a common understanding of the project area, its resources and limitations.

Activities of a "team-building" nature have included: developing a plan for entering the project area; discussing team roles and responsibilities; developing a project work plan; creating a public relations project summary in French and Kinyarwanda; researching and discussing secondary information on the project area with the development of area profiles; visiting other projects together as a team; explaining the project to local administrators and extension agents; interacting with local officials and extension cadre on constraints they face in improving agricultural production; holding field days for on-farm trials; training of extension agents on how to monitor trials.

The team participated in other more structured training events such as a practice session for installing bean variety trials and a work session to review and improve the team's diagnostic survey procedures. Workshops and conferences conducted by CIMMYT and FSSP provided a forum where the team could refine concepts and methods of FSR/E. Project sponsored scholarships to some of these events have included individuals other than core team, such as station researchers and extension agents.

Involving Extension

Since FSIP has only begun its field activities, the project has concentrated on research, which has yet to produce proven extendable interventions. This has not hindered us from involving the extension system. The role of extension during this phase is to work along side researchers and farmers functioning as gatekeeper and communications linkage, helping to insure the needed multidirectional flow of information from farmer to the researcher and back.

Despite a lack of formal agreements to delineate how we are to work together, the administrative and agricultural extension agents in the project's communes have cooperated with us to:

- identify priority work-related constraints to doing agricultural extension in the project area;
- choose farmers for our diagnostic survey;

- explain the project to farmers during the diagnostic survey;
- conduct the diagnostic survey;
- improve our diagnostic methods;
- select farmers for our on-farm trials;
- explain FSR/E methodology to farmers;
- install researcher-managed bean and sweet potato variety trials;
- select communal and institutional sites for adaptive research trials;
- provide "umuganda" labor (donated labor required by government one day per week) for trial site land preparation;
- monitor on-farm research trials
- conduct farmer field days to evaluate bean variety research;
- conduct farmer a field day on cover crops and agro-forestry research in progress.

During a series of diagnostic interviews with extension agents they identified four major problems which the project is attempting to address: (1) lack of technical skills, (2) too few agents to do the job well, (3) lack of mobility and (4) lack of basic extension and office materials.

A training program is in progress to build the agents' capacity to assist with farming systems research and extension. Training topics have included project goals and objectives, FSR/E concepts and methods with a focus on the research activities in progress such as diagnostics methods, layout of trial plots and the purpose of the research. The team conducted a three-day workshop on bean disease and insect identification and control in cooperation with specialists from ISAR and the International Center for Tropical Agriculture (CIAT). One output of related field work assignments provided an inventory of bean diseases and pests in the project area. The extension agents also developed a descriptive list of bean diseases in Kinyarwanda to be used in future training events.

We have worked with each communal agricultural office to program our work into their busy schedules to avoid scheduling conflicts. In addition, the project has hired additional agents to alleviate the work load. These agents will be fully integrated into the communes in which they work. The project intends to address their mobility problem through provision of a means to obtain bicycles and motorcycles. Limited basic office supplies and field materials will also be provided to increase their effectiveness.

Farmers as Partners

Area farmers are important partners in the research process. They were initially interviewed to help determine resource levels, problems and concerns. Their collective contribution helped to establish research priorities. These included soil fertility and erosion control research as well as bean and sweet potato variety research. Their participation in trial monitoring is solicited and their evaluation of trial results is critical to how we continue to operate.

Typical of the interaction between farmer and researcher is the observ-ation by the women planting our bean plots that we planted too thickly, especially for the climbing variety. During first round monitoring, one of our agronomists took plant counts from trial plots and the farmers' bean fields which surrounded our plots. The farmers helped him count. Farmers' fields had

a density 100,000 plants per hectare higher than our trial plots. This information was shared with each farmer on the spot. Similar interaction took place with the farmers regarding sweet potato trials. Women observed that our ridging methods would produce bigger potatoes but planting flat as they do would produce higher yields. Harvest time will tell who is right. We already know that the women, who do all the work in sweet potato production, are not favorably impressed with the additional work required to ridge the plantings.

Field days for farmer training and interaction have been organized both at planting and harvest time in each of the four communes. We have shared our philosophy and methodology with farmers. Harvest field days provided a forum for evaluating results and for planning ahead to the next season. The acid test is when a farmer wants to continue the exercise, even though the trial results of a particular season are not too promising. Farmers helped us determine, for example, that our bean trials were planted early for some micro-climates. Their beans, planted two weeks later, were not as hard hit by bean diseases. Whether their bean yields will be influenced by late season aphids and dry weather awaits the after-harvest trial results. Even with the quite variable results of this season's trials, the farmers still want to cooperate for another season. They also know that we value their input.

We brought 35 farmers with their agricultural extension agents to Rwerere for a field day on soil fertility management and erosion control. These farmers had never set foot on a research station before. The group visited plots established by our soil scientist for cover crops and leguminous shrubs. The purpose of the research was discussed and the results evaluated together with the farmers. It was hoped from this experience that a few of the farmers might be willing to farm test these interventions. Before the end of the day they all begged to cooperate. They decided amongst themselves that they would team up for both the cover crop and alley cropping trials.

Including Station Researchers

ISAR researchers at both Rwerere and at Rubona have been very supportive of our work, both in defending its existence and providing technical back-stopping where needed. Bean researchers at Rwerere and Rubona (including specialists from CIAT) helped conduct the bean disease and insect pest work-shops for extension agents. Station researchers also provided recommendations for varieties to be used in bean and sweet potato variety trials.

The project in turn, is beginning to generate information needed as feedback for the researchers to modify or reinforce their station research activities. Furthermore the project is providing the station researchers opportunities to interact with both farmers and extension agents. This strengthens information flows and increases the likelihood that station based research activities will be relevant to address farmers' needs.

Establishing Formal Linkages

Formal recognition and establishing proper communications with national and local authorities is basic to project success. Official presence involves both formal agreements and information linkages. Formal agreements specify working relationships and responsibilities of all parties within the framework of the project. Information linkages provide a basis for dialogue on issues

and for feedback essential for evaluation and adjustment to improve project effectiveness.

The FSIP team has a positive official presence. The team met with ministerial, prefectural and communal authorities for formal introductions and to explain the project purpose and proposed work plans. Two-way dialogue on issues and responsibilities is evolving. Local administrators and agricultural technicians are anxious to assist with project implementation. Communal agricultural agents working with the project do so, based on goodwill and informal arrangements. Feedback from the official community is assisting the team to evaluate and adjust for improved effectiveness.

The project still lacks memoranda of understanding which establish the formal relationship of the project to the local extension agents and provide for a coordinating committee to monitor project activities. Misunderstandings about the purpose of the project have surfaced as a result. Many officials hold the expectation that FSIP should be an integrated rural development project with an emphasis on infrastructure. There is another expectation based on interpretation of certain phrases in the project paper that the project will take on full financial support of the extension service in the four communes along with their work programs. This is particularly interesting to local authorities, since many of the communes are having financial difficulties and are subsequently laying off extension agents.

IT'S NOT AN EASY ROAD

While the project has had a measure of success in building an effective relationship between research and extension, it has not been an easy road, nor will it be. The current level of success is built on a lot of goodwill, and perhaps on anticipation of "better things to come". Being a relatively large agricultural project generates high expectations about what all that money can and should do. Some well placed government officials have said that it seems a waste to spend all that money on "research". As badly as formal working arrangements need to be spelled out, there continues to be substantial dis-agreement on the substance of the accords and how our funds should be managed.

The questions are myriad, new territory un-scouted, tolerances often low and resistance to change sometimes high. There are no handbooks or maps to help steer a course through the mine fields of institutional change. We currently face the serious question of whether or not the project should take over all on-going extension activities and themes as well as all extension staff. Can we physically and financially do so without jeopardizing our commitment to FSR/E? We do not believe we can. If not, what can we do for extension more than is now being done to make it a more effective service for disseminating tested interventions coming out of the FSR/E process? Is training and involve-ment in the on-farm research enough? Are the supply of more agents, better transport and logistical support the answer? Should we take on some existing themes? Or will current extension themes conflict with technologies or recommendations that will soon come out of the FSR/E process?

CONCLUSION

These and other questions point to challenging days ahead for the project. Much progress has been made already in institutionalizing the FSR/E process in the project area. Approximately 120 fanners and their extension agents are participating actively in various phases of on-farm research. For the first time farmers are able to communicate directly with researchers to influence the relevance of on-station as well as on farm research. A new three-way partnership of farmers, researchers and extension agents is evolving. Elements of the top down structure of enforcement will sometimes inhibit useful two-way information flows until the problem is addressed by national policy. Misunderstanding of project goals and objectives will surface until appropriate accords formally spell out working relationships. A great opportunity is before us. There is much work to be done.

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Table 1

Civil Subdivisions of the Project Area		
Communes	Sectors	Cells
Butaro	10	53
Cyeru	15	47
Nyamugali	12	36
Nyarutovu	12	53

Table 2

Number of Extension Personnel by Commune				
	Butaro	Cyeru	Nyamugali	Nyarutovu
Agronomes	1	2	2	2
Monagris	7	6	4	8
Sectors	10	15	12	12

FIGURE 1

RWANDA'S EXISTING RESEARCH AND EXTENSION STRUCTURE

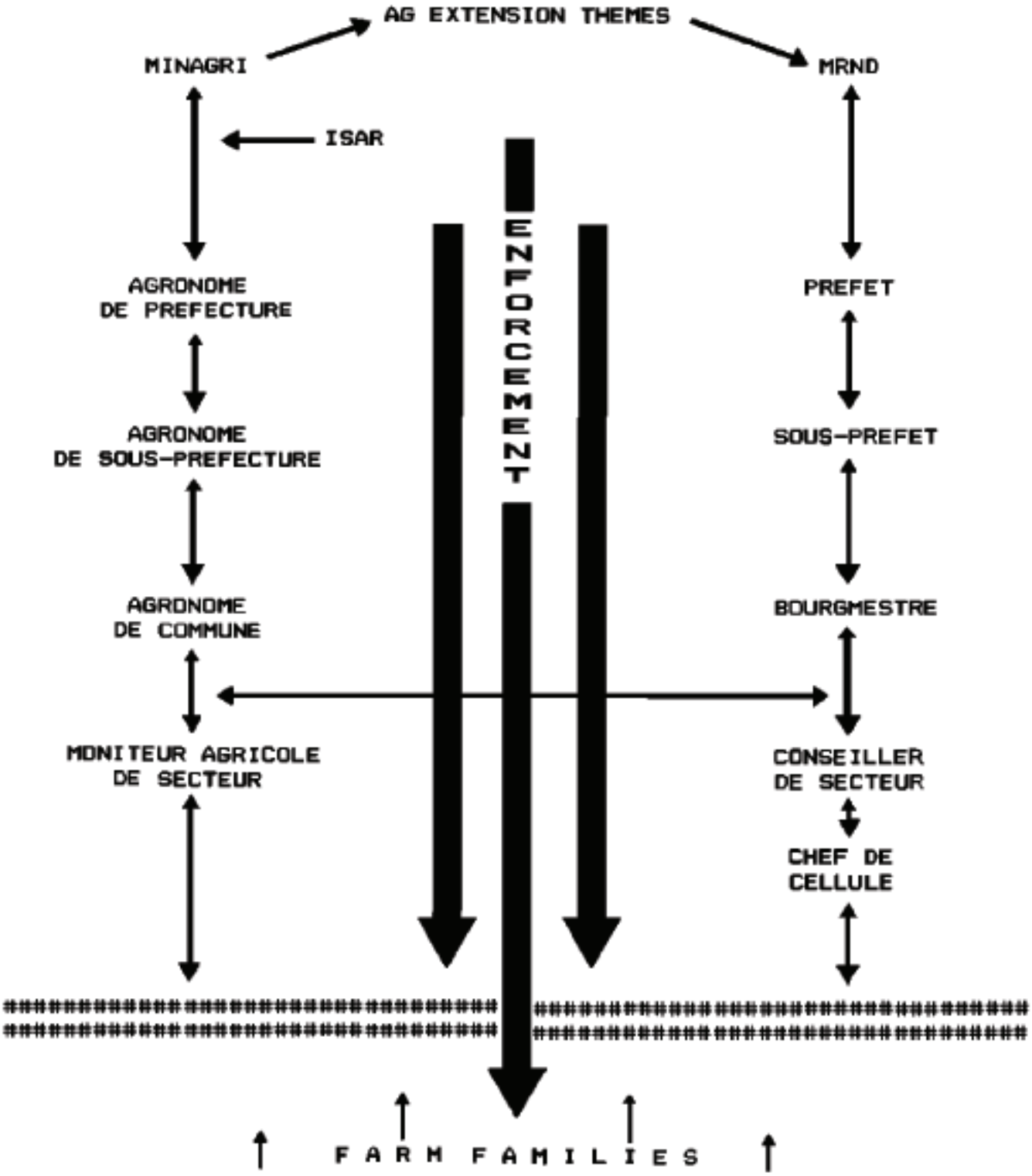
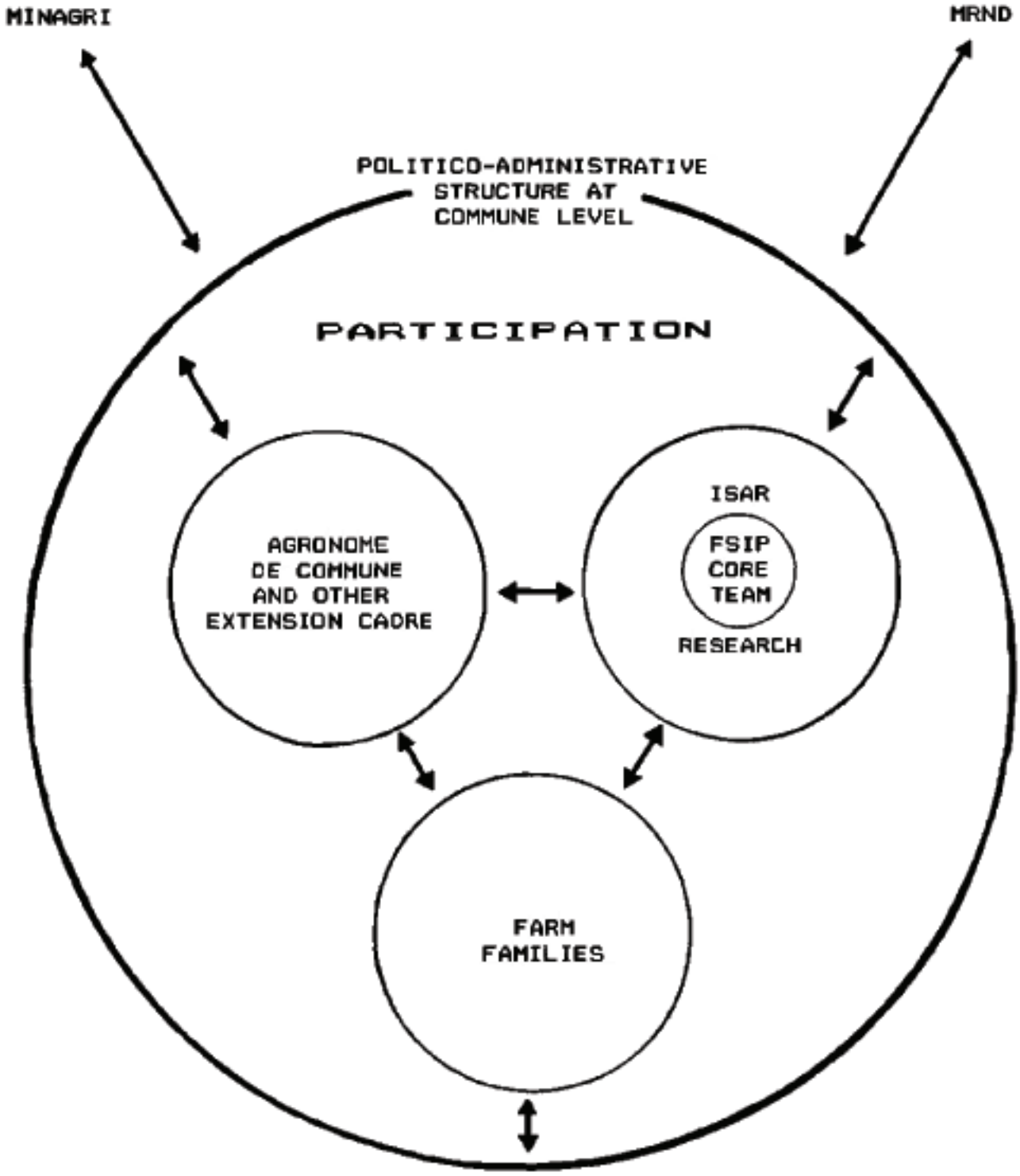


FIGURE 2

IMPROVED RESEARCH AND EXTENSION STRUCTURE
The Expanded Team



AN INSTITUTIONAL BUILDING ADAPTIVE RESEARCH PROTOTYPE: A CASE STUDY OF FARMING SYSTEMS RESEARCH/EXTENSION TRAINING FOR THE BAY REGION, SOMALIA

Projects 649-0113/649-0112

Long, Beckstrand, Boateng, Smith**

A continuing debate centers on which research-dissemination model should be used in Third World countries. Should we export our very successful experiment station generation of technology that is disseminated through extension, or is the farming system research perspective a better model? Those that prefer a model that involves the farmer in defining the research and in testing and trial verification prefer the FSR model. The jointly sponsored USAID, World Bank, and African Development Fund Agricultural Farm Management Extension Training has been short of research and supervisory support for the mandated Training and Visit System.*

There is increasing support for participatory involvement in efforts to maximize farm-family livelihood and quality of life in Third World countries. Top-down dissemination of technology often fails for many reasons. For example, sustainability of practices, after the inputs of donor intervention, requires a level of commitment seldom reached without participation. Needs assessment of farm families are usually lacking. The technology being trans-ferred is generally not individualized to specific needs of farm families; therefore, it is accepted only by the more progressive farmers.

*T & V methodology implemented in Somalia was very narrowly defined as Top-down technology transfer, with no transition for Agent/Farm Family input involvement.

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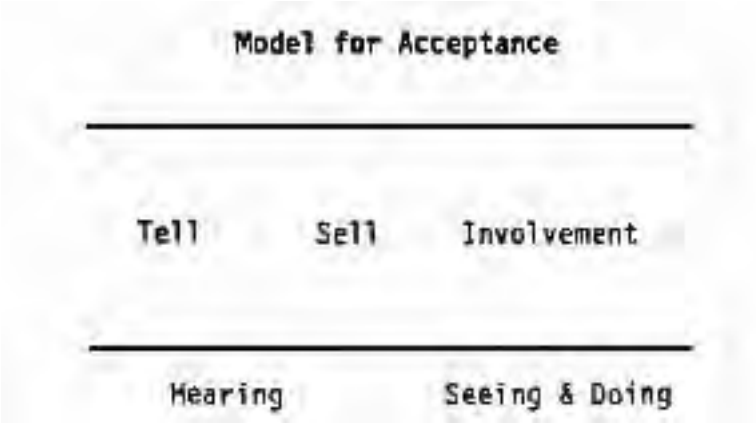
The application of the maximum participatory involvement concept is vital for implementing effective agricultural programs in developing countries. Adaptive Research is developed and utilized to the degree of Research/ Extension/ Farm Family correlation. If any one of these groupings are slighted, breakdown of technology transfer results.

It is most important to understand that this maximum participating involvement is not automatic but rather happens in logical sequence. The normal and very natural procedure is identified in the following diagram:



This illustration shows that some acceptance is generated by both telling and selling, but that a much greater amount of acceptance takes place when people are involved. This implies that involvement should be at all stages of program development -- from needs assessment through adoption of technology. It also implies that, for most people, introduction to an idea or a particular technology might logically begin with telling or selling. Any extension methodology, when utilizing this approach to Adaptive Research development and Technology Transfer should be most effective. T & Y as implemented in Somalia, employed the first two stages but has never included the third stage, thus creating a very stagnant programming environment. For this reason the AFMET Project has generally accepted the programming concepts included in Farming Systems Research/Extension Perspective (FSR/EP) to reinforce the mandated T & V system.

The preliminary efforts by the AFMET staff members for conducting FSR/EP was most encouraging. Extension staff response at the Region, District and Village levels was most positive. Farm families responded quite enthusiastically to surveys conducted in selected villages. District Extension Officers, Specialists and Field Extension Agents and Farmers in selected villages, collaborated in conducting both verification trials (on-farm comparison trials) and recommended demonstrations to be used for Farmer's Field Days. Excellent agronomic data was collected by FEA's, DEO's and Specialists. In turn, the AFMET staff analyzed and evaluated the data, providing most meaning-ful information for Extension staff to share with farm families.

From the beginning it was recognized that a link was missing in this process. Extension rather than Research was providing technical packages for delivery. Even though it was recognized from the beginning of the Project that this missing link was greatly needed, response from the Central Agricultural Research Station had been minimal. However, more recently the staff of the Bay Region Research Project 649-0113 (Wyoming) had been working closely with the Extension staff in both plot work and training. They responded to our invitation for Institutional Building development to establish a FSR/EP programming prototype that could be generalized to other areas of Somalia and, with appropriate modification, transfer the prototype to other Developing Countries. A research farm, adjacent to the Extension Training Center (ETC) in Baido, provided the setting for Research & Extension staff to cooperate.

In order to expedite this Institutional Building/Adaptive Research team effort between Extension and Bay Region Research, the two Projects contracted with Utah State University for two TOY personnel (Agricultural Educator and Extension Specialist) to provide, with the assistance of USU Project staff, a training workshop for the combined Research and Extension staffs of the Bay Region.

Rationale for Training

Farming Systems Research/Extension Perspective looks at technology development and technology transfer from the perspective of the farm family. Identified felt needs are considered as problems and/or opportunities for program resolvement. Some of the needs become research problems. Farming Systems Research studies the context within which farm families live and work. Therefore, Extension liaison members of the team need to be trained to study more than the cropping and animal production systems within the control of the members of the farm household. More specifically, they need to study the interrelationships between cropping and animal systems and socio-economic factors. The socio-economic factors include the farm families goals, access to resources, choices of enterprises and management practices (Shaner, 1983).

Extension is expected to generate farm-family perceived opportunities that suggest research either at the Research Station, at the Educational Training Center (ETC), or on farm. Research designs and conducts the on-station trials, assists in designing and installing the trials at the ETC and assists Extension in designing the on-farm trials that are conducted by the farmer with close FEA supervision. A particular problem might logically require testing at any or all of the three levels. A trust relationship between the farm family and FEA will insure farm family commitment to the Research/Problem Solving team.

It was hoped that the training provided might overcome bureaucratic impediments present in Somalia between Research and Extension. This was seen to be an institutional building process to promote team work and trust through productive experience. A concern addressed in planning the program reported here was the structure of a training experience that involved both Extension and Research in a production experience.

An even more encompassing desired outcome of this training was to stimulate an interest within the Central Agricultural Research Station Administration to become involved in this cooperative Institutional Building mode. If this were accomplished it was felt that the bureaucratic impediments between Research and Extension would be overcome. Even before the two-week workshop was completed, interest was expressed by the CARS Administrator to conduct a similar workshop in the Lower Shebelli Region to develop similar Research/Extension Institutional Building between CARS and Extension. Exten-sion and Research are "ready" for this relationship; plans for such training also include working with private entities as well as other governmental organizations/institutions.

Prior to this training, programming emphasis was directed toward agronomic production. It was decided that farm family members involvement with inter-disciplinary interactions should be taught. It was also agreed that FSR/EP training should include group process theory and practice that builds social skills and problem solving critical thinking skills. Participants needed instruction to gain an appreciation for integrative deci-sion making to include clearly stated goals, positive use of confrontation, de-emphasis of negotiation and majority-minority impact on decision making and the generation of the best solutions that logic and reasoning can derive through wide participation of the total group. The training was also designed to have FSR/EP support and reinforce the mandated T & Y methodology so that FEA's would become more effective in technology transfer through gaining a better understanding of the farmers they are to serve (Hildebrand, 1981).

The Training Program

The training program began with a presentation to the Research and Exten-sion participants by Dr. R. Bukur, Director of the Bonka (Bay Region) Research Station. He explained agronomic research and small plot design and analysis

(Gilbert et al., 1980). His presentation provided introduction to assignment of Extension participants to assist in harvesting research plots. Research and Extension teams harvested plots from 8:00 a.m. to 11:00 a.m. on six of the ten days of the Workshop. Participants were sensitized to the need for accuracy of experimentation, sound plot design, and procedures for data collection, analysis and subsequent recommendations for appropriate testing. Thus the team concept including Extension and Research personnel working together was primary.

The remainder of the schedule for each day, 11:30 a.m. to 1:00 p.m. and 3:30 to 6:00 p.m. was devoted to the following topics:

1. Explanation of research (explained above)
2. Explanation of Extension Services in Somalia
3. Explanation of Farming Systems Research — linking Extension to Research as support to T & V
4. Explanation of why FSR/E
5. The approaches for FSR/E — Interdisciplinary program development (Gilbert et al., 1980)
6. Practicing Sondeo surveying with Role Playing for effective Agent-Farm Family interaction
7. Developing practical Sondeo using interdisciplinary approach
8. Conducting actual Sondeo

The Sondeo rapid rural reconnaissance was seen to be of major importance for this workshop. Role playing and practice resulted in participants gaining skill and confidence in doing surveys and an initial appreciation for systematic study to combat potential erroneous assumptions and biases in interpreting farm problems.

Small group problem solving was used to generate topics for the survey instrument and, later, to analyze survey results. Instructors observed group

interaction and reinforced the stages of group development that represent the individual members movement from commitment to personal goals to a commitment to group goals.

9. Identifying direction for a detailed survey through use of an interdisciplinary approach including agronomists, economists, and extension personnel
10. Preparing questionnaire using interdisciplinary approach
11. Practicing questionnaire administration using role play
12. Actual administration of the questionnaire
13. Questionnaire analysis/Group problem solving process
14. Creating awareness of use of the survey results by both Research and Extension in developing appropriate technology testing with the farmer - the "down-stream" approach
15. Recounting the process and suggesting possible constraints
16. Planning and conducting exploratory survey (Sondeo) as a portion of the two-day Monthly Training of FEA's that DEO's were scheduled to conduct

This ten-day Workshop directly preceeded the two-day Monthly Training for FEA's. In anticipation for using these local FEA's to survey the villages within their responsibility, the Regional and District Extension Officers, supported by the Research staff, planned for teaching Sondeo the first five-hour day and supervising a survey of a nearby village the second and final day of the Monthly Training. The FEA's enjoyed the Sondeo experience and gained a better perspective of farmers' problems from the experience. Analysis of the data collected was shared with all Somali RED's, Subject Matter Specialists and DEO's at the Annual Extension Training at AFMET in February.

Evaluation

The Research and Extension participants gave a positive response in their evaluation of the Workshop. They were asked to rate the Workshop on a ten-point scale from -5 to +5 for "group interest", "take-home value", "new ideas to me", "content clarity", "participation", "usefulness", "opportunity for individual participation", and general effectiveness. The ratings fell in a range of 3.9 to 4.4 with a mean of 4.0. In addition, the instructional staff positively rated participants progress toward a working understanding of FSR/EP as well as increased understanding of T & V. Summary

Sufficient models exist to impact positively on research technology transfer in developing countries. There are many limitations to the application of these appropriate models. Turf protection is all too common between the bureaus in LDC's. The difficulty found in obtaining cooperation among these different entities often limits progress toward effective technology development and transfer.

The effort to institutionalize cooperative relationships between Research and Extension in Somalia represents an attempt to foster teamwork at the grass roots level. The Annual Training conducted sequentially for the Bay Region Research Project (Rainfed), and the AFMET Project USAID Projects, proceeded on the assumption that Research and Extension need to establish a close working relationship. Conditions were "right" for this development to succeed. For the 18 months prior to this training project, Research and Extension had been seeking ways to support each other to maximize the use of facilities and program staff.

The workshop was scheduled at a time that conflicted with research plot harvest. This problem was treated as an opportunity for team building. Extension staff were assigned to help Research staff harvest in the mornings

and Research staff joined Extension in afternoon training sessions. Extension participation in harvesting research plots and Research staff participation in extension method study provided a positive first step toward building a sustainable cooperative environment.

While all purposes of exploratory surveys for FSR/E were not reached in this ten-day training, real progress was made. Both Research & Extension staffs gained a working understanding of FSR/EP program development. Specifically they gained practice in developing survey skills and a beginning understanding of farm-family problem identification process. Categorization into domains, useful for designing intervention strategies, was internalized during plan of work preparation.

A very significant application of this annual training for District Extension Officers and Subject Matter Specialists was their subsequent two-day monthly training for FEA's. This was accomplished by preparing them to teach Sondeo techniques to FEA's which they accomplished immediately upon completion of their own training program. Preliminary evaluation indicates that this transfer was most successful.

It is expected that this training, with appropriate follow-up, will provide Research and Extension a means to maximize participatory involvement as part of a total team effort in providing intervention for resolvement of farm-family problems. Heretofore, the T & V Extension methodology practiced in Somalia has been top-down -- research to farmer approach, with little concern for farmer-specific orientation and subsequent participation in problem solving. A broadened perception of T & Y resulted from this training program.

This instructional program was planned and conducted as a step towards development of a prototype that would serve Somalia and development projects in other Third World countries.

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BASIC INTERVIEWING AND NOTE-TAKING SKILLS FOR THE INFORMAL SURVEY IN FARMING SYSTEMS RESEARCH AND EXTENSION

Rosalie Huisinga Norem*

INTRODUCTION

This paper identifies and discusses basic interviewing and note-taking skills and techniques for use in the informal survey in Farming Systems Research and Extension (FSR/E). The material is a synthesis of ideas and experiences in a variety of field settings, both from training and project work. It is hoped that organizing the material in this fashion will provide a resource for future training and project efforts.

Farming Systems Research and Extension methodology continues to develop, being refined and focused through experiences in various countries. This process has led to an increased reliance on the informal survey (sondeo, reconnaissance survey, rapid rural appraisal) in diagnosis and design (Frankenberger and Lichte, 1985; Franzel, 1984).

There are a number of resources on the planning and implementation of informal surveys (Collinson, 1981; Frankenberger and Lichte, 1985; Franzel, 1984; Hildebrand and Ruano, 1982; Rhoades, 1982; and Shaner, et al., 1981). These sources focus more on the objectives, logistics, and organization of information from the survey than on the actual interview skills used. There is a recognition that the interview(s) with informants is different from an formal survey interview using a questionnaire. Since questions are not structured ahead of time, and no standard format is used for recording information, the researchers must decide how best to accomplish the objectives of an informal survey. There is a difference of opinion about some issues, such as taking notes during interviews and whether topical outlines should be used (Collinson, 1981, Hildebrand and Ruano, 1982, and Shaner, et al., 1981). There are no hard and fast rules.

Frankenberger and Lichte (1985) point out the importance of continued development of methodology for conducting informal surveys. Since the interview itself is a critical component which determines the success of an informal survey, improved interview skills and techniques are a necessary part of this methodological development. But sources focusing on interview skills tend to work with examples from communication and helping services (Egan, 1975; Metzler, 1977; Norem, 1980; and Patton, 1980). While it is not realistic for all FSR/E researchers to become expert qualitative interviewers, there are several general pointers that can improve interviewing skills. The ideas in the following sections of this paper seek to identify some important issues about the informal survey interview in FSR/E, and provide guidelines and alternatives related to the asking of

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questions and note taking. Reseachers may make appropriate choices among these alternatives depending on their situation.

THE INFORMAL SURVEY METHOD

Attributes of the informal survey

The distinguishing features of the informal survey method, as used by FSR/E, give us a point of reference for identifying why interviewing guidelines can be useful. Franzel (1984) summarizes these features in 5 points. (1) Interviews are conducted by researchers, not enumerators. (2) Interviews are not structured through the use of questionnaires. (3) Sampling is basically purposive. (4) Data collection is a dynamic process, with continual evaluation and reformulation of data needs. (5) Interviews are conducted over a period of 1-8 weeks.

As stated earlier, FSR/E researchers are not necessarily expert qualitative interviewers. They may have less actual interviewing experience than enumerators typically used in formal surveys. But the researchers often have the advantage in an informal interview of being able to pick up on comments or observations that can give direction in uncovering new information. Their knowledge of the project and research objectives, plus their disciplinary expertise, can give them a high degree of sensitivity to such opportunities in an interview. A basic understanding of how to probe effectively for more information adds even more to this advantage.

The lack of a previously developed questionnaire also provides opportunities for learning about the respondent's frame of reference and the prioritization of problems. This lack of structure, however, must be used effectively to be expansive rather than limiting. Skills that facilitate a good interview positively exploit this potential.

Since the selection of a sample is not random, the most must be made of each interview opportunity. A small number of interviews are often used to design and implement trials. Researchers need to be aware of differences between group and individual interviews, and the special aspects of in-the-field interviewing.

The dynamic data collection process provides an opportunity for evaluation and reformulation. It also requires an awareness that somewhat different techniques and skills may be less useful in early interviews than in interviews held later in the survey. For example, certain kinds of probing and clarification questions may seem threatening if used too soon, but not if they are used in context of previously obtained data.

Because the length of time for interviewing varies, skills in effective focusing during an interview can help a researcher make the most of the time frame available. All informal surveys may be

dynamic, but working with a one-week time frame involves some limitations not present with an 8-week time frame. For example, different focusing techniques may be chosen because of time limitations.

Objectives of the study

The objectives of an informal survey are a second point of reference for assessing the usefulness of various interviewing skills and techniques for a particular study. Decisions about whether to use a "blank mind" or topic guidelines (Shaner, et al., 1981) can be made more appropriately if considered in terms of survey objectives. If the objectives of a study require certain specific information be obtained from the informal survey, then it is illogical to choose techniques which depend primarily on the informants to determine the substantive direction of the interview. Researchers should be sure to include questions necessary to obtain essential information, while retaining the flexibility of the informal survey approach. It may be more helpful to think of the variation from a "blank mind" to topic guidelines as a continuum, rather than a dicohotomy. Where on this continuum researchers choose as a starting place for a survey should be influenced by the objectives of the study. (See Frankenberger and Lichte, 1985, for a discussion of determining the objectives of a study.)

PROVIDING CONTEXT FOR THE INTERVIEW

There are several interviewing techniques that are relevant for the FSR/E informal survey. These can be thought of as ways to provide context for the interview. The researcher has a picture of the whole situation, or environment of the interview, including those aspects discussed above. This is the "context" of the interview. In the broadest terms, one can assume that learning about farming systems is the context of interviews in a FSR/E survey. The respondent must be included in this context, and it is the researcher's role to facilitate this. Specific techniques to consider are discussed below.

Establishing rapport

This technique is discussed in the farming systems literature cited earlier. Several helpful guidelines are provided by Rhodes (1982) and quoted below.

1. Don't go directly to the subject at hand. The farmer should be first be greeted according to local custom. Farmers should be treated with respect (if the local language requires it, use the "polite" form of address) (p.17).

2. Treat farmers with courtesy. Don't talk to the farmer from a vehicle. ... Open the conversation with locally accepted polite talk about the weather, how his crops are doing, or the price of potatoes. Tell him exactly who you are, why you wish to talk, and the nature of your work (p. 17).

3. Observe the situation to make sure the context is conducive to an interview. ... Sometimes farmers can suggest the best time and place to continue (p. 17).

4. ... be natural and relaxed while guiding the conversation to a fruitful end (p. 17) .

5. One method that gains farmer cooperation anywhere in the world is the straight forward, honest admission on your part that the farmer is the "expert" about farming in his area and you are the learner (Rhoades, 1980:17).

Among other things to consider in building rapport is the necessity in some areas to meet with village leaders before interviewing individual farmers. Sometimes the initial contact with farmers takes place during such a group setting. The basic guidelines above still apply, but it is important to remember that even though the farmer has information about you from the group setting, there may be some confusion about why you want to visit individual fields or households. Don't forget to include some general polite conversation when beginning individual interviews.

It is desirable to interview more than one person in a household or compound. Men and women may perform different tasks in the farm management process. This means establishing rapport with both men and women. Depending on local customs, this often requires a somewhat different protocol. Including women on interview teams can facilitate building rapport with women. In some situations, other women in a household, or neighbors, may join you as you start an interview. Be flexible about working with a group situation.

Attending behavior

To establish rapport, and to conduct a productive interview, requires that the farmer(s) perceive you as interested and involved in the process. This depends to a large extent on your attending behavior. Attending behavior is simple and easy to do. Yet lack of attending in human interaction is very common. Think of times when you have felt some one was not listening to you. Probably they were not giving you attending cues.

There are verbal and nonverbal elements of attending. Proximity is important. Norms about comfortable proximity vary, but if you can adapt to local customs, your attending behavior will be enhanced.

Being relatively relaxed physically conveys the message that you are comfortable with the other person. Eye contact is another nonverbal measure of attending, but should not be so constant as to appear rude according to local customs.

Verbal attending behavior includes "minimal encourages" to the person talking. Repetition of one or two words, saying "um-hummm, " and interjecting one-word questions indicate you are paying attention. This usually comes naturally, and should not be overdone.

Listening is the essence of attending. It may seem obvious, but studies show people in general tend to have poor listening skills. Good listening can be learned, and will improve the quality of information from an interview, as well as your attending behavior. Some simple helps are to (1) try to suspend your value judgments about what is being said, so you hear, rather than start to prepare rebuttals in your mind; (2) make it a habit to summarize mentally what the other person is saying every few minutes; (3) pay attention to nonverbal cues from the other person; and (4) put other interesting distractions in the environment on hold for the moment. If you are working with an interpreter, make sure he or she is not directly between you and the respondent.

Types of questions

It is easy to think of interviewing as asking questions. It is true that questions are an important part of an interview situation, but care should be taken to use them as appropriately as possible. Several different types of questions, and guidelines about their usefulness are listed below.

1. "What" questions are relatively non-threatening and very useful in FSR/E surveys. "What are your major cash crops?" "What did you grow on this land last year?" "What types of inputs are you using?" These questions all ask for fairly straight forward, factual information.

2. "How" questions are also usually non-threatening and factual. But "how" questions can be very good open-ended questions. They ask for more explanation than "what" questions. "How do you prepare your fields?" or "How many times do you weed?" are very different than "How do you decide which crops to grow?" The more process description being called for, the more open ended the question.

3. "When" questions are critical to FSR/E surveys. "When do you plant?" "When do you harvest?" These are questions which allow you to compile a cropping calendar. They tend to be factual, and not particularly open questions. This means too many "when" questions can turn an interview into a question and answer session with little opportunity for an overall picture of things.

4. "Who" questions are similar to "when" questions in terms of eliciting short answers. But "Who does the planting?" and "Who makes decisions about what and when to plant?" are very different from each other. The second is asking for a description of a process of decision-making. Answers to such a question need to be considered with other observations and knowledge about the customs in an area.

5. "Why" questions are useful questions, but should be used with care. It is easy to interpret a "why" as a challenge to what has been said or done, or a demand for justification. Think of alternative ways to ask "why" questions. For instance, "Can you explain how you decided to plant maize on this plot?" rather than "Why did you plant maize instead of beans?"

6. Open vs. closed questions. An open question allows further exploration. A closed question delimits the response. Since an informal survey seeks to gain as total a picture as possible, open questions are usually better than closed ones. Think about how to phrase questions so they are open. Compare the following examples.

Closed—"Are there times during the year when you need to hire labor?"

Open—"How do you manage when work piles up?"

The first question is really asking for a yes or no answer. The second question encourages a response which could include information about labor-sharing between households, keeping children out of school, hiring migrant laborers, etc.

7. Direct vs. indirect questions. Open questions can be made even more open by stating them indirectly instead of directly.

Direct—"How do you manage when work piles up?"

Indirect—"There must be times when it is difficult to get everything done. I wonder how your family manages during those times."

8. Probing questions are often necessary to get more depth about something. There are 3 basic kinds of probing questions. The first is a detail-oriented probe to add specific information. For example, after finding that a farmer plants maize on a certain field, you may want to ask a probing question such as "What varieties of maize do you plant on your farm? or "Did you plant maize here last year also?" This type of probing question is relatively closed because you are asking for specifics.

The second kind of probe is a clarification probe. It is essential when you do not understand something the farmer tells you, or when

your team realizes data are confusing or conflicting. Sometimes a clarification probe can be as simple as repeating the last few words the farmer said. Other times it needs to be thoughtfully worded to make sure you get clarification without putting words in the farmer's mouth. Saying you are not quite sure you have the information straight, and asking the farmer to clarify it for you is straight forward and effective.

A third type of probe is an elaboration probe. It is asking for an expansion of information about a topic. A simple elaboration probing technique is to ask a person to talk a bit more about something, e.g., "Can you tell me a little bit more about how you prepare your fields for planting?" This is an open question and invites expansiveness.

Observation

While you are conducting an informal survey, you have opportunities to observe characteristics of villages, households, fields, farming practices, etc. Observations provide data in addition to data provided by respondents. Practice comparing your observations to what farmers are saying. You may want to ask questions about what you observe. Practice keeping your observations separate in your mind from what farmers do or say. They are two different kinds of data.

When asked to describe something, we often give our interpretations rather than a report of behaviors or objects. Learn to differentiate between what you observe and the interpretation you make from your observations. Compare the examples below.

There are 3 young men in the field with backpack sprayers. Insecticide containers are setting by the side of the field.

It is mid morning. Four women are taking turns drawing water from a well. They carry the water to nearby garden plots. Each women waters 3 separate plots.

There are backpack sprayers available to farmers in the area, and an insecticide supply also exists.

Women in the village work in communal gardens with individual plots. They do not work together on each others plots.

The first two examples above report observed behaviors. The last two give an interpretation of observed behaviors. The interpretations may be correct, but observed behaviors are more useful data. Interpretations are more correctly based on multiple observations and interviews.

Positive feedback

All of us rely on positive feedback from others to reinforce our behaviors. When farmers give us their time and share their knowledge, it is important to give them positive feedback about the helpfulness of their input. It is obvious and natural to say "thank you" at the end of an interview. But giving reinforcement during an interview, such as "this is very helpful" or "you have explained that very well" can facilitate continued interest. Care should be taken to use positive feedback honestly and not "make up" something, but opportunities arise in almost every interview for genuine positive feedback. It should not be overdone.

Sharing experiences

Sharing your farm experiences briefly can facilitate rapport. As Rhodes points out (1982:17), "farmers always like to compare notes." This can be done if an opportunity arises during an interview to comment on your experiences in similar situations or with similar problems. Try to avoid getting into an advice-giving mode. Sometimes inviting comparisons can serve to clarify issues. Do not switch the topic by elaborating on your experiences.

Focusing

Each of the techniques discussed above can be used for focusing. It is included here only to remind you that the researcher determines when and how much focusing occurs in an interview. It is a matter of balancing the goal of getting an overall picture with objectives related to certain kinds of information. Selective focusing results in a productive interview.

INFORMATION DISCREPANCIES

Discrepancies in information inevitably surface during informal interviews. Team members often find this frustrating and confusing. Information discrepancies do not mean a team has done a poor job of interviewing or recording information. They are data in and of themselves. They provide direction for further exploration and clarification. They often suggest new ideas for consideration in the design process. Several common types of discrepancies are listed below.

1. Researcher/respondent. You may observe one thing and be told another.
2. Farmer 1/farmer 2. Each situation is different.
3. Male/female. There are often different perceptions and different experiences based on gender.

4. Group/individual. You may be told one thing in a group situation and something quite different when talking to an individual.

5. Interview 1/interview 2. The same person may tell you one thing one day and something else the next.

6. Team member 1/team member 2. Two people hearing the same interview will sometimes hear different things.

You may decide you want to clarify a discrepancy by further interviewing. It is important not to come across as challenging what someone has told you. The more data you can present to describe your confusion, the better your chances are for understanding why the discrepancy exists. This can be done least threateningly by simply stating something like "I think you said you planted maize on this field and at some point I remember our talking about intercropping with sorghum. I must have gotten mixed up a bit." This specifies the discrepancy but does not turn into an accusation.

If a discrepancy cannot be cleared up, it can be included in the report of the survey. A discrepancy in information does not necessarily mean one piece of information is right and another is wrong. It may mean they are just different.

TAKING NOTES

As stated earlier in this paper, there is some difference of opinion about taking notes during an informal survey. It is very difficult, if not impossible, however, to recall information accurately without taking any notes. Some general guidelines may be helpful.

Don't start the interview with paper and pencil poised. Ease into note taking. Rhoades has good advice. "Whether one should take notes in front of farmers depends on the situation. Be sensitive to your actions (1982:19)." It is not the case that farmers always are uncomfortable if you take notes during an interview. One farmer asked whether a team was not really interested in what he said because no one was writing anything down. Making some notes as a person is talking can confirm your interest and can be introduced by saying something like "If you don't mind I will be taking a few notes so I am sure I remember the points you make."

Don't try to write down everything. It is not only distracting to the person being interviewed, but it prevents you from listening to what is being said. Use a couple words or a short phrase as a "memory jogger" for what you want to recall. "Maize intercropping-no" will remind you that a farmer said he or she did not intercrop maize with beans or sorghum.

Save specific notes for details you want to be sure and remember. Examples might be crop yield or type of fertilizer. If you are working with a team member, you can decide to divide up the kind of details each of you will record.

Organize your notes as you take them. You can make it a habit to put observations and interpretations in two separate columns on a page. This will help you keep them separate later when recall is hazy. You can also write memory joggers about cropping practices in one quadrant of a page and those about animals in another quadrant. Experiment to find the best system for yourself.

Leave a little space between notes so you can easily go back and jot down another word or two about the same topic or idea.

Sometimes a space left at the top of the page is a good place to jot down reminder words to help you remember to come back to certain ideas in an interview, when you don't want to interrupt what is being said at the moment.

There are several good tools for organizing information from an informal survey, such as a cropping calendar, task chart and food availability calendar (See the Farming Systems Support Project FSR/E Training Units, Vol. I, Unit VII). These are not intended as fill-in-the-blank instruments during the interview. They may provide general content guidelines for use in organizing notes as suggested above.

Good notes during interviewing will facilitate, but not take the place of, careful recording of information after the interviews. Post interview report writing is discussed in detail in several farming systems papers (Frakenberger & Lichte, 1985; Franzel, 1984; Hildebrand, 1981; Rhodes, 1982; and Shaner, et al., 1981).

WORKING WITH AN INTERPRETER

Interviews should be conducted in the local language. It is desirable, but not always possible, for them to be conducted without using interpreters. Working with an interpreter makes the use of the techniques and skills discussed above more difficult because communication is not direct between the researcher and the farmer. The importance of having questions interpreted in the same style or framework they are posed must be stressed. A researcher can pay careful attention to nonverbal cues to help assess how the interview is going, and check with the interpreter for clarification from time to time. It is desirable to practice working with your interpreter ahead of time if possible. He or she can then also become familiar with good interviewing skills.

In working with a team and an interviewer, it is important that at least one of the researchers have good attending behavior and not make it seem that the interpreter is doing the interview. Other team

members, however, may want to alternate the task of taking fairly complete notes, since it is more difficult to remember what was said when the communication was not direct. This can be done fairly unobtrusively during interpretation.

TRAINING SUGGESTIONS

Each of the skills discussed above is best learned through practice. Role play situations with triads work well in a workshop setting. One person practices asking questions, a second plays the role of a farmer, and the third person observes the interaction, making notes as an observer. Then feedback is exchanged about how questions were asked and answered. Then roles shift with a new situation, until each member of the triad has a chance to play each role, interviewer, observer, and farmer.

Videotape with feedback is especially helpful in such training, but may be impossible in many situations.

Doing a demonstration role play showing ineffective and effective use of questions, and demonstrating other skills, is also helpful.

Another role play could provide the opportunity for researchers to practice taking notes, discriminating between behaviors and interpretations. They could then give and receive feedback to help them discriminate more clearly.

The FSSP FRS/E Training Units, Volume 1, Diagnosis in Farming Systems Research and Extension, includes a script for good and bad mock interviews (pp. T-51-T-57). This approach could be used for training related to specific techniques and skills.

Specific training exercises depend to a large extent to the time available. The suggestions above can be part of informal survey methodology training in a workshop, and can be tailored to time constraints.

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CONTRIBUTION OF CROPPING SYSTEMS PROGRAM'S RESEARCH AND EXTENSION ON RURAL POOR: A CASE STUDY OF RATNANAGAR CROPPING SYSTEMS SITE

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INTRODUCTION

Multiple cropping or the growing of more than a single crop in a piece of land in a year has been practiced in developing countries and it has offered several opportunities for subsistance farmers to increase their farm productivity (Andrews and Kassam, 1976; Harwood and Price, 1976; Hildebrand, 1976; Harwood, 1973; Beets, 1982; Brady, 1982; Pendleton, 1982; and Gomez and Gomez, 1983). Cropping system has been defined as the cropping patterns used on a farm and their interactions with farm resources. Carangal (1977) mentioned that cropping systems are dependent on physical and socio-economic environments thus highly environment specific. Farming system, a broader term than cropping system, has been defined by the MSU farming systems research group as a unit consisting of a human group and the resources it manages in its environment, involving direct production of plant and/or animal products, as well as the consumption of these products. From this perspective, a farming system is a result of interaction among interdependent components (Axinn, 1981).

Research on cropping systems can apply systematic approach to the study of farm's crop-production enterprises by utilizing the available physical resources (such as rainfall, solar radiation, soil types, etc.). It takes into account the relationship among the various crop production activities, between the crop production enterprise and other production or consumption activities on the farm, or both, and between other environmental factors (physical, institutional, social, and economic) and the farm's crop production enterprise (Zandstra, 1977).

Increasing empirical evidence shows that the needs of small farmers have not been adequately addressed in development programs in the Third World over the past twenty years (Khan, 1978; Poleman and Freebairn, 1973). Many development projects have been introduced without sufficient understanding of the environment to where small farmers operate. Public investment in agricultural research have been spent in matters other than what was required by the small farmers, who are the major consumers of research results. Anderson (1979) gave an excellent analysis of the factors influencing misallocation of research resources in many LDC's. Allocation of funds for research often has been based on:

1) expressed needs of more influential farmers who often hold non agricultural jobs in the society;

2) research that will appeal to professional "peer groups" of the researchers; and

3) types of technology that have been developed in advanced countries.

Resultingly, the link between the small farmers and the research organizations has weaken (Stavis, 1979). Learning from this experience, the cropping systems research (CSR) approach starts with the farmers to establish a link between the farmer and the research institution and funding agency, thus counterbalancing the "top-down" experiment station research approach. The cropping systems approach has the potential of providing the small farmers an avenue for communicating their needs to the research workers and the funding agencies. Two types of farming systems research programs have emerged in recent years - the "upstream" and the "downstream". The "upstream" has been conducted on and off station for many years by the International Agricultural Research Center (IARCs). Meanwhile, the "downstream" research is designed to rapidly identify and test possible innovations which can easily be integrated into existing farming systems. It focuses on close interaction with farmers via on-farm trials to consequently draw discipline oriented research on "upstream" programs (Gilbert et al., 1980). Similarly, cropping systems research programs are also "upstream" and "downstream" types as in farming systems research.

The primary aim of the CSR approach is to increase the productivity of the cropping system in the context of the entire range of private and societal goals, given constraints and potentials of the existing farming systems. Productivity can be improved through the development of relevant technology and complementary policies which increase the welfare of farming families in ways that are useful and acceptable to them and to the society as a whole.

The common cropping systems in Nepalese subsistence farm are centuries old characterized by sequential cropping, mixed cropping, and relay cropping. The subsistence farmers, knowingly or unknowingly, follow these patterns. Moreover, the traditional agronomic research were less beneficial for small scale farmers because of inadequate extension methods as well as the farmers' unwillingness to accept new technology (Sah and Flinn, 1981; Hildebrand, 1984). In Nepal, there has been no literature reported before the last decade about research results that improve the farmers' existing cropping (or farming) systems. Hence, a felt need of research addressed to the farmers cropping system must be tried in the farmers' fields and suitable research methodology have to be developed and followed.

In 1977, the Integrated Cereals Project (ICP) with its cropping systems program (CSP) in collaboration with the Agronomy Division of the Department of Agriculture, Nepal started research efforts on cropping systems. On-farm research started initially in Sukchaina and Bahuwari (Parsa district) and Pumdi Bhumdi (Kaski district) cropping system sites. At winter of the same year, three other sites - Chauri Jahari (Rukum district), Lele (Lalitpur district), and Khandbari (Sankhuwasabha

district) were added areas of research. In 1980, the area included Ratnanagar (Chitwan district). The general characteristics of the cropping systems sites are given in Table 1 and the major ecological zones of Nepal showing these sites are shown in Figure 1.

The CSP program of Nepal aimed to increase total production to eventually improve the farmers' welfare through land use intensity (multiple cropping) . It was perceived that the increase in crop yield will be realized with the better use of the available resources (CSS, 1979). The International Rice Research Institute's (IRRI's) cropping systems research methodology was followed (Zandstra, 1977; Zandstra and Carangal, 1977). It also aimed at developing technologies by non-traditional research systems with the integration of research and extension working with farmers in their field (ICP, 1985).

The ICP report on the different cropping systems revealed that the program is carried out through logical steps of technology transfer: 1) development of technology in farmers' fields for specific agroclimatic and socio-economic conditions, 2) verification of the technology, and 3) extension of the technology on a wide scale. The successful launching of the pre-production verification trials in different parts of the country for different patterns especially for low to mid hill rice-wheat and maize-wheat cropping patterns (Lipinski and Rizal, 1984) and the production program in 17,000 ha for wheat in 1983/84 (Bolo and Malla, 1984; Sarkar and Chitrakar, 1984) was attributed to the farmers' readiness to change and acceptance of new farming practices (Bolo, 1984). Likewise, the impact study on rainfed area of Sukchaina demonstrated the rapid adoption of crop production technologies as a result of cropping systems activities (Singh and Sayre, 1985). However, the cropping systems approach, though successful at increasing the cropping intensity and the total yields of the several farmers, none of the study so far has shown its impact or contribution on small and marginal farmers - the rural poors. Hence, the present study aimed to assess the influence of CSP research and extension activities on the small and marginal farmers in nearby communities of Ratnanagar cropping systems site which represents the inner terai of Nepal. The specific objectives for this study were:

1. To identify the present cropping systems of small and marginal farmers residing close to cropping systems research site;

2. To determine the extent to which the small and marginal farmers residing close to the cropping systems research site have adopted the cropping systems technology recommended by the CSP of the ICP;

3. To find out the difference in total crop yields per unit area between the participant farmers and the small and marginal farmers; and

4. To suggest and recommend policies and priorities for the benefit of small and marginal farmers of the CSP of the Department of Agriculture.

Importance of the Study

This study shows the impact of CSP's research and extension on the small and marginal farmers. It also provides information on the existing cropping systems of these farmers. Finally, it suggests and recommends priorities for the benefit of these farmers to policy makers and development workers.

Definition of Terms

Small and marginal farmers refer to the farmers who have a farm size below 15 katthas (0.5 ha) and whose income generates mainly from this land.

Participant farmers refer to the farmers who participated in the CSP of ICP at Ratnanagar cropping systems site. These farmers are also called "farmer co-operators" in ICP publications.

Non-participant farmers refer to the farmers who have not participated in CSP of ICP at Ratnanagar. In this study non-participant farmers included only small and marginal farmers.

Multiple cropping index refers to the sum of the areas planted to different crops harvested during the year divided by the total cultivated area times 100.

Land utilization index refers to the number of days during the year which crops occupy the land divided by 365 and multiplied by 100.

Cropping system refers to the cropping patterns followed in a farm and their interactions with each other. Cropping systems are environment specific and depend on physical and socio-economic factors.

Lowland fields refer to the rice fields that are flooded during at least part of the year and usually have bunds to trap and retain water. If such fields have artificial irrigation facilities, they are called irrigated lowlands otherwise, if these fields are dependent on natural rainfall, they are called rainfed lowlands.

Upland Fields refer to those fields that are not submerged during any portion of the cropping season.

MATERIALS AND METHODS

Physical Characteristics of Ratnanagar Cropping System Site

Ratnanagar Village Panchayat is located on the Bharatpur-Hetauda road about eleven kilometers southeast of Bharatpur (Fig. 2). The total population in the panchayat as of December 1984 was 10,265, of which 5,579 were males and 4,686 were females. The total number of houses and livestock sheds are 1,510 and 1,018, respectively. Total cultivated area is estimated at 1,516 ha, of which 694 ha (45.8%) is lowland and

822 ha (54.2%) is upland. About 2% of the total area is occupied by houses, offices, schools, and markets. The altitude of the panchayat is 305 meters above sea level.

The bazaar or market named "Tandi" includes a branch of Nepal Bank Ltd., a chemist store, a health centre, a malaria office, a few agriculture offices, a primary and a secondary school and a campus for higher education. A number of tea shops, small stores and restaurants are found in the bazaar. Water from streams, wells and taps is available.

Adjacent to Ratnanagar Panchayat and located to the north side of Bharatpur-Hetauda road is Panchakanya Village Panchayat. The total population as of December, 1984 was 7,640, of which 4,041 were males and 3,589 were females. The total number of houses and livestock sheds are 1,314 and 873, respectively. About 90% of the total area is upland and only 10% is lowland.

The annual rainfall pattern of Ratnanagar is unimodal. On the average, it involves eight consecutive dry months with less than 100 mm of rainfall, and four consecutive wet months with more than 200 mm of rainfall. The rainfall begins in May, peaks in July, and declines rapidly after September. There is little or no rain from October to April (Fig. 3) . Figure 3 shows the annual precipitation from 1981 to 1984, and the monthly maximum and minimum temperature means from 1980 to 1984. The panchayat has a maximum temperature of about 37 degrees centigrade in May and June, and a minimum temperature of about 9.5 degrees centigrade in January.

The soil of Chitwan Valley is composed of alluvial plains and terraces developed by the three main rivers, i.e., the Narayani in the north, the Lothar in north-east, and the Rapti in the south and southeast. Geologically, they consist of moderately coarse to medium textured deposits underlined by fine sand and compacted gravel in depths generally varying between 1.2 m and 1.8 m. Eastern tributary terraces are the main land group and hydromorphic soils are the most dominant soil in Ratnanagar Panchayat (Mathema et al., 1979). The texture of soil varies from fine sandy loam to silty loam. The major land types are rainfed upland, rainfed lowland, and irrigated lowland. The major crops grown in the area are lowland rice, upland rice, maize and mustard and the minor crops are wheat, peanut, soybean, cowpea, lentil, lathyrus, and potato.

The main reason for selecting Ratnanagar cropping systems site with Ratnanagar and Panchakanya villages for this study was the researchers' accessibility to these villages and their knowledge with the area.

Selection of Household Heads

a. Selection of non-participant farmers. A list of household heads belonging to small and marginal farmer category in Ratnanagar village panchayat was prepared with the help of local panchayat officials by using the latest census taken by the panchayat. Similarly,

small and marginal farmers of some adjoining wards of Panchakanya village panchayat (wards 6, 7, and 9) were also identified and listed. The list was discussed with the CSP site coordinator and the participant farmers were excluded from the list. Then forty farmers were selected randomly who served as non-participant farmer respondents in this study.

b. Selection of participant farmers. A list of all the participant farmers in the CSP from the Ratnanagar an Panchakanya village panchayats was prepared with the help of CSP site coordinator. The site coordinator was requested to identify the participant farmers who belong to small farmer category. Fifteen farmers were identified and interviewed to find out the difference in total crop yields between CSP participant farmers and non-participant farmers.

In the cropping systems research and extension (CSR/E) program, the participant farmers were selected on the basis of land type and the farmers' willingness to extend interests and cooperations to research. Whenever possible, small farmers are selected either with the personal contacts or through meetings with the farmers where the objectives of research are clearly explained to the farmers. Presently, about one hundred farmers from Ratnanagar and Panchakanya Panchayats have participated in the program, of which about 20% are small farmers with less than 0.50 ha land and about 15% have less than 0.20 ha land (Personal communication with site coordinator). Since only 20% of the participant farmers have land less than 0.5 ha (15 katthas), 40% of the participant farmers in this study represented small farmers with land between 15 to 25 katthas.

The CSP's research and extension in Ratnanagar started five and a half years ago while in Panchakanya it began the spring of 1984. The respondents (80%) in this study were selected from Ratnanagar Village Panchayat and the rest from the adjoining wards of Panchakanya Village panchayat (wards 6, 7, and 9). This was done with an assumption that the contribution of CSP in adoption of improved cropping systems practices by small and marginal farmers could be more in the adjoining areas than in far areas.

Data Collection Procedure

Data for this study were collected by using a pretested interview schedule. Each interview was conducted in the home or the farm of the respondent only after a rapport building session of at least 10-15 minutes.

The records and documents of the CSP were also reviewed as needed to supplement the survey information. Further, participant observation techniques also helped in understanding the problems related to farmers and their farming systems.

Methods of Data Analysis

The data were analyzed using descriptive statistical tools such as means, percentages, ranges, and frequency counts. Graphs, frequency polygons and histograms were also prepared in some cases.

Most of the data described the changes in the cropping systems technology as historical technology (technology adopted five years ago) and new technology (technology adopted at present) for both participant as well as non-participant farmers. The major land types in which the CSP's research and extension concentrated on irrigated lowlands, rainfed lowlands and rainfed uplands, hence, the changes in the cropping systems technology were shown in these land types for both participant as well as non-participant farmers.

Multiple cropping index (MCI) and land utilization index (LUI) for all the land types were computed by using the following formulae and expressed as percentages:

$$MCI = \frac{\text{Total Crop area}}{\text{Total Cultivated Area}} \times 100$$

$$LUI = \frac{\text{No. of days crops occupied the land}}{365} \times 100$$

The gross income obtained from the crops was computed according to the prevailing market price in Narayanghat as of the first week of September, 1985. The market price of farm produce is given in Appendix 1.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Respondents

The discussion on this section is based on Table 2. Most of the respondents in this study were migrants from the hills. The majority (60%) were found residing in the village for more than 15 years. Tharu and Darai were the indigenous residents of the village.

The age of the respondents ranged from 23 to 78 years, with an average of 42 years. The majority of the respondents were below 45 years of age. The mean age of non-participant and participant farmers was 42 and 44 years, respectively.

The respondents belonged to different caste and ethnic groups. Brahmin, Chhetry, Tharu, and Darai were the major ethnic groups in the area. Damai, Tamang, Puri, Gurung, and Newar were also found in the area.

The household size of the respondents ranged from 2 to 11 with an average of 5.9. It should be noted that almost half (42.5%) of the family members were children below 14 years of age. The household size of participant farmer was relatively larger (mean = 7.0) as compared to

non-participants (mean = 5.5). It was also observed that Tharu and Darai families were mostly of extended type.

Almost half (47.5%) of the non-participant farmer respondents in this study can read and write. The literacy rate was even higher (73%) for participant farmers. It should be noted that only a few (14.5%) respondents in this study indicated no literate family members in their households.

The size of land holding of non-participant farmers ranged from 2.5 to 15 katthas with an average of 9.6 katthas.* In case of participant farmers, the range was 5 to 15 katthas and the average size was 14.3 katthas. Lowland irrigated, lowland rainfed and upland rainfed were three major categories of land found in the area. The majority of the respondents' farms included more than one category of land and thus farmers were practicing different cropping patterns accordingly.

Cropping Patterns in Irrigated Lowlands

Farmers practiced different cropping patterns in the area. Cropping patterns followed by the participant and the non-participant farmers before the start of the CSP and at present are given in Table 3. It was observed that two-fifth (41% for non-participant and 40% for participant) of the farmers have adopted rice-mustard-maize pattern.

Table 4 shows the recommended cropping patterns by the CSP for different land types and the number of participant and non-participant farmers adopting those patterns. Out of 7 patterns recommended for irrigated lowland, only rice-wheat-maize and rice-mustard-maize were adopted by the participant farmers, and mainly 3 patterns, rice-wheat-maize, rice-mustard-maize, and rice-fallow-maize were followed by the non-participant farmers. The majority of both the participant and the non-participant farmers were adopting rice-mustard-maize pattern. It should be noted that, mungbean despite having great potentiality in providing protein for the farmers as well as in improving the soil fertility, no one among the respondents followed rice-wheat-mungbean and rice-fallow-mungbean patterns. It could be attributed to the perception of the subsistence farmers to satisfy their need of cereal food before protein, or, these farmers do not have much knowledge about mungbean.

Rice-wheat-maize pattern gave the highest total pattern yields of 7.4 and 7.8 t/ha with the gross income of $1,375.6 and $1,439.4, respectively, for the participant and the non-participant farmers. Rice-mustard-maize pattern gave the total pattern yields of 6.0 and 4.13 t/ha, with the gross income of $1,530.6 and $1,200.4, respectively for the participant and the non-participant farmers. It should be noted, however, that non participant farmers reported higher total yields for

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*30 katthas is equal to one hectare.

rice-wheat-maize pattern as compared to the participant farmers. This could be attributed to the smaller farm size of the non-participant farmers who tend to be more productive (Table 5).

The higher percentage of adoption of rice-mustard-maize cropping pattern in the irrigated lowland by the small and marginal farmers could be traced to the CSP's emphasis on this pattern. Since rice-wheat-maize gave the highest total pattern yield, farmers in the area may also be encouraged to follow this pattern by including some soil amendment crops so as to maintain soil fertility and the yield.

The frequently mentioned problems by both participant and non-participant farmers for cropping in irrigated lowlands were diseases and insects in crops, and unavailability of improved seeds, fertilizers and pesticides when needed.

Cropping Patterns in Rainfed Lowlands

In case of rainfed lowlands, farmers followed different cropping patterns. Cropping patterns followed five years ago and at present are presented in Table 6. It was observed that 50% of the non-participant and 66% of the participant farmers were now adopting rice-mustard-maize pattern. Other major patterns followed were rice-mustard-maize+cowpea by the non-participant farmers (25%) and rice-mustard-fallow by the participant farmers (16%).

Out of the 5 patterns recommended for the rainfed lowlands by the CSP, few participant farmers adopted rice-wheat-fallow and rice/lentil-fallow patterns and fewer non-participant farmers adopted rice-mustard-fallow pattern. It was observed that rice-fallow-Sesbania sp. and rice-chickpea-fallow patterns were not adopted by the farmers (see Table 4) . The Sesbania sp. as a green manure crop, has great potential to increase the yield of rice in the farmer's fields of Ratnanagar (Shrestha, 1985). In this regard, more research and extension is required on rice-fallow-Sesbania sp. pattern. The reason for non-adoption of rice-chickpea-fallow was early maturing rice variety required to adopt this pattern. But, adoption of this pattern with the combined use of an early maturing rice variety like Bindeshwari and a high yielding chickpea variety, Go-332, could increase the economic status of Sukchaina farmers (Singh and Sayre, 1985). Hence, the seeds of Bindeshwari and Go-332 should be supplied to the small and marginal farmers of Ratnanagar and an extensive extension should be imputed for adoption of rice-chickpea-fallow pattern. Recommendation of this pattern will be of less importance to the small and marginal farmers if seeds of Bindeshwari and Go-332 are not supplied to such farmers.

Rice-mustard-maize pattern gave the highest total pattern yield of 6.4 and 5.4 t/ha with the gross income of $1,486.1 and $1,233.6, respectively for the participant and the non-participant farmers (Table 7) . Although this pattern has not been recommended by the CSP to the rainfed lowlands, majority of the non-participant and the participant farmers adopted this pattern and obtained the highest total

pattern yield and gross income. Despite the small farm size of these farmers, they were able to grow several crops in the same land for their subsistence. The negative relationship between multiple cropping index and farm size was also evident in case of non-participant farmers who were following rice-mustard-maize+cowpea pattern. Hence, the rainfed lowland farmers of Ratnanagar should be encouraged to follow the rice-mustard-maize pattern with possibly cowpea or other legumes.

As in case of irrigated lowlands, the frequently mentioned problems by both groups of farmers in rainfed lowlands were insects and diseases in crops, and unavailability of improved seeds, fertilizers, irrigation and pesticides when needed.

Cropping Patterns in Rainfed Uplands

Several types of cropping patterns were followed by the farmers in rainfed uplands (see .Table 8) . Of all the patterns followed, maize-mustard was the major pattern followed by 60% of the non-participant farmers. Other patterns followed by these farmers were maize+cowpea-mustard (15% farmers), upland rice-mustard (7.5% farmers), and upland rice-mustard-maize (7.5% farmers). In case of the participant farmers, maize+cowpea-mustard (25% farmers) and, maize+cowpea-mustard+lentil (25% farmers) were the major cropping patterns followed.

Of the three patterns recommended for rainfed uplands, the maize-mustard pattern was adopted by 12.5% of the participant and 60% of the non-participant farmers. Other recommended cropping patterns, maize-maize/wheat and maize/soybean-fallow were not followed by both the non-participant and the participant farmers (Table 4). Cropping patterns involving maize, mustard and cowpea were adopted by 50% of the participant farmers but only 15% of the non-participant farmers adopted the cropping patterns involving these three crops (Table 8).

Upland rice-mustard-maize pattern gave the highest total pattern yield of 6.5 and 5.4 t/ha with the gross income of $1,487.2 and $1,265.0 for the participant and non-participant farmers, respectively. Other patterns that gave higher yield for participant farmers was maize+cowpea-mustard+lentil (4.1 t/ha) and for non-participant farmers was maize+cowpea-mustard (2.98 t/ha). The maize-mustard and maize+cowpea-mustard patterns gave slightly higher total yields to the non-participant farmers (2.81 and 2.98 t/ha, respectively) as compared to the participant farmers (2.7 and 2.65 t/ha, respectively) providing more gross income to the former group than the latter group (Table 9). Probably, the little attention of the CSP for research on rainfed uplands or to the participant farmers affected the CSP's recommendations.

Although maize-mustard pattern is followed by a majority of the non-participant farmers, these farmers may still be encouraged to grow cowpea as an intercrop with maize, and lentil as an intercrop with mustard so as to increase the total yield of the pattern as well as to

improve the soil fertility. This was already experienced by the participant farmers. Upland rice-mustard-maize pattern should be tested for a few more years in small and marginal farmers' fields and should measure its potential to grow long duration crops all the year round especially in spring under rainfed uplands. The frequently mentioned problems were diseases and insects in crops and unavailable improved seeds and fertilizers.

Land Use

Figures 4 and 5 show the land utilization indices and multiple cropping indices. The figures show the extensive changes in land use that occurred 1979 onwards in all the land types for both the participant and non-participant farmers (see Appendix 2).

The greatest change in land use occurred in rainfed lowlands for both the participant and non-participant farmers. This was attributed to the increased cropping intensity by growing two or three crops a year. Findings indicated that there was no change in land use in rainfed uplands mainly because of difficulties of growing three crops a year. The increase in cropping intensity in irrigated lowlands during the past five years could be attributed to the available irrigation facilities thus, growing an additional crop during spring season. It should be noted that the increase in multiple cropping index in rainfed lowlands was higher for non-participant farmers than for participant farmers but in other land types, it was higher for participant farmers than that of the non-participants. The reason for higher multiple cropping index in the case of non-participant farmers under rainfed lowlands could be attributed to smaller farm size (Gomez and Gomez, 1983) as well as individual characteristics of the farmers in the involvement on farming activities.

Much of the increase in cropping intensity has resulted from the adoption of spring maize in both irrigated lowlands and rainfed lowlands. In addition, some farmers reported growing early maturing rice varieties like Bindeshwari, Malika and CH-45 that can be harvested early and allow land preparation for winter crops such as wheat, lentil and mustard.

Livestock Raised

Livestock play an important role in the household economy. Cows, buffalo, sheep and goats, and chickens were the major types of livestock raised by the respondents (Table 10). Farm animals such as buffalo, goats and chickens were raised by some farmers on a share basis and none of the respondents raised improved breeds of livestock. It was observed that the participant farmers tended to raise more livestock as compared to non-participants, and the size of livestock holding tended to be directly related to farm size. Unavailability of feed, especially green forage and fodder was the frequently mentioned problem in raising livestock.

Farmers Response to Some Aspects of Cropping Systems Program

The findings of this study indicated that about three-fourths (77.5%) of the non-participant respondents were aware of the presence of the CSP in Ratnanagar and about two-thirds (72.5%) of them indicated knowledge about the functions of the CSP.

A majority of the non-participants (67.5%) indicated no contact with technicians working with CSP. Of those who indicated contact, most of the contacts were initiated by the farmers and the purpose of contacting technician were mainly to solve disease and insect problems. Technician-initiated contacts were mainly for asking some land for the cropping systems research program.

Of those who reported participation in the CSP, one-third of them were presently participating by growing crops as per recommendation of technicians in a limited area (2-3 katthas) of their farm. The provision inputs such as seed, fertilizer, pesticides and supervision of crops by the technicians for the research plots (2-3 katthas) under the program was appreciated by the majority of the participant respondents.

On perception of respondents about the usefulness of the CSP, findings of this study indicated that an overwhelming majority (87%) of the participant farmers and about one-third (35%) of the non-participant farmers indicated the program as useful (Table 11) . However, majority (60%) of the non-participants did not give their opinion about the usefulness of the program.

CONCLUSIONS

The following points listed as conclusions from the findings of this study are limited to small and marginal farmers and may be less valid for big farmers.

1. Rice, mustard and maize were the major summer, winter, and spring crops, respectively, in irrigated and rainfed lowlands. Similarly, maize and mustard were the major summer and winter crops in rainfed uplands.

2. Rice-mustard-maize was the major cropping pattern followed by both the non-participant and participant farmers in irrigated lowlands. In rainfed uplands, maize-mustard was the main cropping pattern followed by non-participant farmers but maize+cowpea-mustard-lentil was the major cropping pattern followed by participant farmers.

3. Among the cropping patterns recommended by the cropping systems program for different land types, rice-mustard-maize and rice-wheat-maize were adopted by both the non-participant as well as participant farmers in irrigated lowlands. In rainfed lowlands, participant farmers adopted rice-wheat-fallow and rice/lentil-fallow, whereas, non-participant farmers adopted rice-mustard-fallow pattern.

In rainfed uplands, non-participant farmers adopted maize-mustard-fallow pattern very extensively while the participant farmers adopted maize+cowpea-mustard+lentil instead of maize-mustard pattern.

4. Total pattern yield and gross income were highest for rice-wheat-maize and rice-mustard-maize cropping patterns for non-participant and participant farmers, respectively, in irrigated lowlands. But in rainfed lowlands, the total pattern yield and gross income were highest for rice-mustard-maize for both the non-participant and the participant farmers. And in the rainfed uplands, upland rice-mustard-maize pattern had the highest total pattern yield and gross income for both types of farmers.

5. In irrigated lowlands, total crop yields per unit area per unit time in case of rice-wheat-maize pattern was slightly higher for non-participant farmers but in case of rice-mustard-maize pattern, it was higher for participant farmers. In rainfed lowlands, the total crop yields in case of rice-mustard-maize pattern was higher for the participant fanners; and in rainfed uplands also, the total crop yields in case of upland rice-mustard-maize pattern was higher for the participant farmers as compared to the non-participant farmers. Because of the higher crop yield per unit area per unit time for participant farmers, the total gross income was also higher for the participant farmers as compared to the non-participant farmers in all the land types.

6. Multiple cropping indices and land utilization indices increased dramatically as compared to indices five years ago in irrigated and rainfed lowlands for both the non-participant and participant farmers. However, in rainfed uplands, there was no increase in land use indices for both types of farmers.

7. Livestock had played an important role in farming systems. The size of livestock holding tended to be related to farm size. Participant farmers raised more livestock as compared to the non-participant farmers. Further, the crop yield per unit area of a small farm tended to be directly related to the number of farm animals raised in the farm.

8. More numbers of participant farmers expressed the usefulness of CSP than the non-participant farmers.

To sum up, considering the adoption of some improved crop varieties and use of fertilizer, the small and marginal farmers in the area were benefited to some extent from the CSP. However, the extent of benefit received by the participant farmers was higher as compared to the non-participants and thus, there seems to have enough room to expand the benefits of the program among the small and marginal farmers in the area.

RECOMMENDATIONS AND POLICY IMPLICATIONS

On the basis of findings, discussions and conclusions, the following recommendations and suggestions are made. The future research and extension of CSP should look at the following suggestions and recommendations in fixing their priorities and policies for the CSR/E.

Priorities Recommendations

1. Since no increase in land use indices were obtained for the past five years in rainfed uplands, it is necessary that the research activities focus on such lands so as to benefit the small and marginal farmers since 54% land of Ratnanagar and 90% land of Panchakanya are of rainfed upland types, and small and marginal farmers usually have such lands.

2. Although mustard was found to be the major winter crop in all the land types, farmers were not growing its improved varieties and hence, the yields were usually low. So, either the farmers should be provided with the improved varieties of mustard or they should be given better agronomic practices for the local variety so as to increase the yield of mustard.

3. Since fingermillet and sesamum are important crops of small and marginal farmers, and these crops can be grown with minimum inputs, future research should include these crops in the testing of alternative cropping patterns.

4. Although cereals are more important than any other crops for small and marginal farmers, grain legumes also deserve attention to other farmers because of their multifarious uses (improving soil fertility, decreasing malnutrition problems and meeting fodder requirements of ruminants, etc.). Hence, cropping pattern involving cereals and legumes should be given priority in research. Early maturing and disease and insect resistant grain legumes like cowpea, mungbean and soybean should be included in the testing of alternative cropping patterns. An extensive extension campaign is recommended to demonstrate the potentials and uses of grain legumes for small and marginal farmers.

Policy Implications

1. Since livestock played an important role in increasing the crop yield per unit area, this component should be added to the research, and the research should be carried with a holistic approach in a farming systems perspective rather than simply in a cropping systems perspective. As suggested by Chambers and Ghildyal (1984), farmer-first-and-last model approach should be followed rather than the normal transfer of technology model approach.

2. Since farmers' fields are complex and are affected by several physical or climatic factors each year, the recommendations should be made only after testing of at least three years in such fields. Recommendations should be specific for each land type.

3. Although, the research is carried out on limited land of the farmer cooperators, the objective of research should strengthen the technology for the farmers. Hence, suitable and economical extension approaches should be developed to efficiently disseminate the appropriate technology. For example, signboards in the research plots and demonstration programs for small and marginal farmers which are lacking at present should be incorporated in the program and be implemented effectively.

4. It is very important that more small and marginal farmers be included in research as the "farmer co-operator" to provide more benefits to the farmers. Hence, at the time of the selection of the farmer co-operator for testing the cropping patterns, small and marginal farmers with different land types should be asked and encouraged to participate in the program. Since these farmers have usually less risk bearing capacity during testing phase because of their small farm size, some sort of incentives or remunerations should be provided in case the crop fails due to aberrant or unfavorable weather.

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ACKNOWLEDGEMENT

Authors are thankful to the Agricultural Development Council (ADC), Nepal for funding this research project. Appreciation is extended to Nancy Axinn for reviewing this manuscript. Resham B. Thapa and Laxmi Baral, IAAS Computer Center, Rampur are also appreciated for formatting and word processing the manuscript.

Table 1. Description of cropping systems sites In Nepal.

	Sites						
	Pumdl Bhumdl	Parsa (irrigated)	Parsa (rainfed)	Chauri Jahari	Lele	Khandbari	Ratnanagar
Elevation (m.a.s.l)	750-1270	150	150	700	1300-1500	460-1100	350
Rainfall (mm)	4000	1500	1500	1100	1800	1200	1800
Rainfall distribution Wet months*	6	4	4	3	4	2	4
Dry months	5	8	8	8	6	6	8
Major soil	inceptisol	inceptisol	inceptisol	Alfisol	inceptisol	inceptisol & ultisol	inceptisol
Major land types	1. Lowland ralnfed 2. Upland ralnfed	1. Lowland Irrigated	1. Lowland ralnfed	1. Upland ralnfed 2. Upland ralnfed in the summer & irrigated winter 3. Lowland irrigated	1. Upland ralnfed 2. Lowland ralnfed 3. Lowland irrigated	1. Upland ralnfed 2. Lowland ralnfed 3. Lowland irrlgated	1. Upland ralnfed 2. Lowland ralnfed 3. Lowland irrigated
Farm size (ha/farm)	0.87	0.85	0.91	0.85	0.63	1.1	0.68

*Wet months refer to those months receiving more than 200 mm rainfall and dry months mean months receiving less than 100 mm rainfall.

Table 2. Summary of selected socio-economic characteristics of the sample respondents.

Characteristics	Percent Responding		
	Non--participants (n= 40)	Participants (n = 15)	Total (%) (n = 55)
Age (household head)			
30 years or less	27.50	13.33	23.64
31-45 years	37.50	40.00	38.19
46-60 years	37.50	33.33	29.09
61 years or more	7.50	13.33	9.09
Length of stay in the village			
5 years or less	2.50	13.33	5.45
6-15 years	32.50	40.00	34.55
16-25 years	42.50	26.67	38.18
26 years or more	22.50	20.00	21.82
Ethnic affiliation of respondents			
Brahmin	42.50	40.00	41.82
Chhetry	12.50	-	9.09
Tharu and Darai	32.50	26.67	30.91
Others	12.50	33.33	18.18
Family size			
1-6 persons	66.50	60.00	65.45
7 and more	32.50	40.00	34.55
Literacy (household head)			
Literate	47.5	73.0	54.5
Illiterate	52.5	27.0	45.5
Farm size			
1-7 katthas	27.5	20.0	25.5
7.1-15 katthas	72.5	40.0	63.5
15.1-25 katthas	0	40.0	11.0

Table 3. Cropping patterns followed before the start of the cropping systems program and at present in irrigated lowlands.

Cropping patterns	Farmers Reporting			
	Non-participant farmers (n = 22)		Participant farmers (n = 5)	
	5 years ago	Now	5 years ago	Now
1. Rice-fallow-fallow	4	2	1	-
2. Rice-mustard-maize	2	9	-	2
3. Maize-mustard-fallow	6	-	-	-
4. Rice-fallow-maize	3	4	-	-
5. Rice-wheat-fallow	1	2	-	-
6. Rice-lentil-fallow	1	-	1	1
7. Rice-lentil-maize	1	-	1	-
8. Rice-wheat-maize	1	2	1	1
9. Others*	3	3	1	1

*Others include rice-fallow rice, maize+cowpea-mustard, rice-mustard, upland rice+maize-mustard, rice-mustard-maize+Sesbania, rice+lentil-wheat, and rice-mustard-maize+cowpea.

Table 4. Distribution of respondents adopting the cropping patterns recommended by the cropping systems program.

Recommended cropping patterns*	Farmers Reporting	
	Non-participant farmers	Participant farmers
Irrigated lowlands	(n = 22)	(n = 5)
a. Rice-wheat-maize	3	2
b. Rice-wheat-Sesbania sp.	1	0
c. Rice-wheat-mungbean	0	0
d. Rice-fallow-mungbean	0	0
e. Rice-mustard-maize	9	3
f. Rice-fallow-maize	4	0
g. Rice-fallow-fallow	2	0
Rainfed lowlands	(n =8)	(n = 6)
a. Rice-wheat-fallow	0	1
b. Rice-faliow-Sesbania sp.	0	0
c. Rice-chickpea-fallow	0	0
d. Rice-mustard-fallow	1	0
e. Rice/lentil-fallow	0	1
Rainfed uplands	(n = 27)	(n = 8)
a. Maize-maize/wheat	0	0
b. Maize-mustard-fallow	16	1
c. Maize/soybean-fallow	0	0

*Source: Terminal report of the ICP, 1985, p. 69.

Table 5. Total pattern yields and gross income for major cropping patterns followed by participant and non-participant farmers in irrigated lowlands.

Major cropping patterns	Average Crop Yield (t/ha)				Gross income ($/ha)
	Summer	Winter	Spring	Total	
			Non-participant Farmers		
1. Rice-fallow (n=2)	3.9	-	-	3.9	823.3
2. Rice-mustard-maize* (n=9)	3.5	0.63	1.04	4.13	1200.4
3. Rice-fallow-maize* (n=4)	3.3	-	1.6	4.7	954.4
4. Rice-wheat-fallow (n=2)	4.7	0.5	-	5.2	1225.6
5. Rice-wheat-maize* (n=3)	3.9	2.2	1.7	7.8	1439.4
			Participant Farmers		
1. Rice-mustard-maize* (n=2)	4.2	0.7	1.1	6.0	1530.6
2. Rice-lentil (n=l)	4.0	0.5	-	4.5	1022.8
3. Rice-wheat-maize* (n=l}	3.9	2.1	1.4	7.4	1375.6

*Cropping patterns recommended by the CSP.

Table 6. Cropping patterns followed before start of the cropping systems program and at present in rainfed lowlands.

Cropping Patterns	Farmers Reporting			
	Non-participant farmers (N = 22)		Participant farmers (N = 5)	
	5 years ago	Now	5 years ago	Now
1. Rice-mustard-maize	1	4	1	4
2. Rice-mustard-fallow	1	1	-	1
3. Maize-mustard-fallow	2	1	2	-
4. Rice-wheat-maize	-	-	2	1
5. Rice-fallow	2	-	1	-
6. Rice-mustard-maize+cowpea	-	2	-	-
7. Others*	2	-	1	1

*Others include rice-mustard+lentil-maize, upland rice+maize-mustard and maize+cowpea-mustard+lentil.

Table 7. Total pattern yields and gross income for major cropping patterns followed by participant and non-participant farmers in rainfed lowlands.

Patterns	Average Crop Yield (t/ha)				Gross income
	Summer	Winter	Spring	Total	($/ha)
		Non-participant Farmers			
1. Rice-mustard-maize (n=4)	3.3	0.65	1.45	5.4	1233.6
2. Rice-mustard-fallow (n=1)	3.4	0.6	-	4.0	997.8
3. Maize-mustard-fallow (n=1)	2.2	1.1	-	3.3	867.8
4. Rice-mustard-maize+cowpea (n=2)	2.6	0.8	0.5	3.9	1002.8
		Participant Farmers			
1. Rice-mustard-maize (n=4)	3.6	0.9	1.9	6.4	1486.1
2. Rice-mustard-fallow (n=l)	3.8	0.8	-	4.6	1175.6

Table 8. Cropping patterns followed before the start of the cropping systems program and at present in rainfed uplands.

Cropping Patterns	Farmers Reporting			
	Non-participant farmers (N = 27)		Participant farmers (N = 8)	
	5 years ago	Now	5 years ago	Now
1. Upland rice-mustard	2	2	1	-
2. Maize-mustard	17	16	4	1
3. Maize-mustard-lentil	3	1	-	1
4. Maize+cowpea-mustard	3	4	1	2
5. Upland rice+maize-mustard	2	-	-	-
6. Maize+cowpea-mustard+lentil	-	-	-	2
7. Upland rice-mustard-maize	-	2	-	2
8. Others*	-	2	2	1

*Others included maize-wheat; upland rice+maize-maize+wheat, and maize-maize.

Table 9. Total pattern yields and gross income for major cropping patterns followed by participant and non-participant farmers in rainfed uplands.

Patterns	Average Crop Yield (t/ha) Summer	Winter	Spring	Total	Gross income ($/ha)
	Non-participant Farmers				
1. Upland rice-mustard (n=2)	2.4	0.50	-	2.4	740.0
2. Maize-mustard (n=16)	1.9	0.91	-	2.81	730.8
3. Maize-mustard+lentil (n=l)	1.8	0.90	-	2.7	710.0
4. Maize+cowpea-mustard (n=4)	2.0	0.98	-	2.98	779.6
5. Upland rice-mustard-maize (n=2)	2.4	0.90	2.1	5.4	1265.0
	Participant Farmers				
1. Maize-mustard (n=l)	2.1	0.60	-	2.70	618.3
2. Maize-mustard+lentil (n=l)	2.1	0.70	-	2.80	665.0
3. Maize+cowpea-mustard+lentil (n=2)	2.8	1.30	-	4.10	1057.8
4. Maize+cowpea-mustard (n=2)	1.9	0.75	-	2.65	656.1
5. Upland rice=mustard-maize (n=l)	3.3	0.90	2.3	6.50	1487.2

Table 10. Types of livestock raised by respondents.

	Percent Responding		
Livestock	Non-participant (n = 40)	Participant (n = 15)	Total (%) (n = 55)
Cows	65.00	80.00	69.09
Buffalo	55.00	66.67	58.18
Sheep and goats	35.00	53.33	40.00
Poultry	52.50	60.00	54.55

Table 11. Perception of usefulness of cropping systems program.

	Percent Reporting	
Usefulness	Non-participant	Participant
Very useful	15	47
Useful	20	40
No opinion	60	6.5
Not useful	5	6.5

Appendix Table 1. Market price of some farm produce in Narayanghat Market as of September 1, 1985.

Commodity	Price ($/t)
Paddy	211.1
Maize	161.1
Wheat	133.3
Mustard	466.7
Lentil	272.2

Appendix Table 2. Multiple cropping index (MCI) and land utilization index (LUI) before the start of the cropping system program (1979) and at present (1985) for different land types.

Land types	Non-participant Farmers MCI		LUI		Participant Farmers MCI		LUI	
	1979	1985	1979	1985	1979	1985	1979	1985
Irrigated lowlands	186	226	60	76	200	259	71	84
Rainfed lowlands	219	278	55	82	192	251	63	84
Rainfed uplands	200	200	54	56	196	200	54	59
Average	202	235	56	71	196	237	63	76

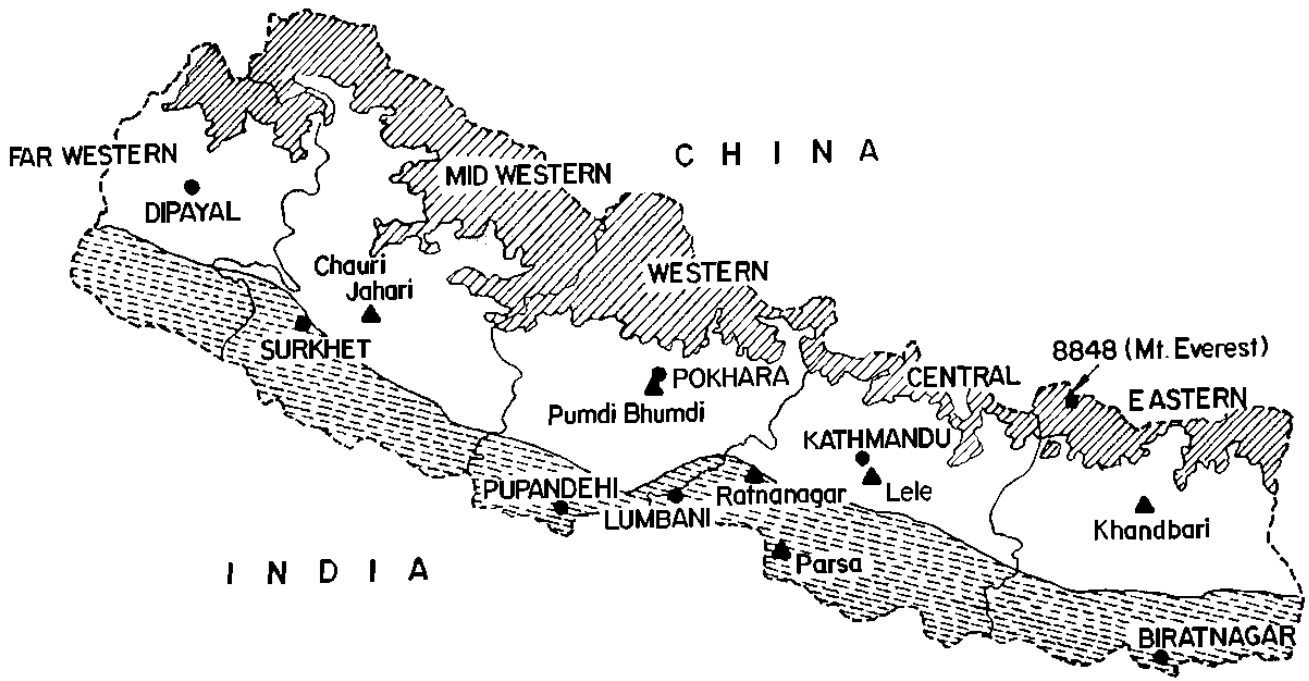

Fig. 1. Three major ecological zones and locations of cropping system sites in Nepal.

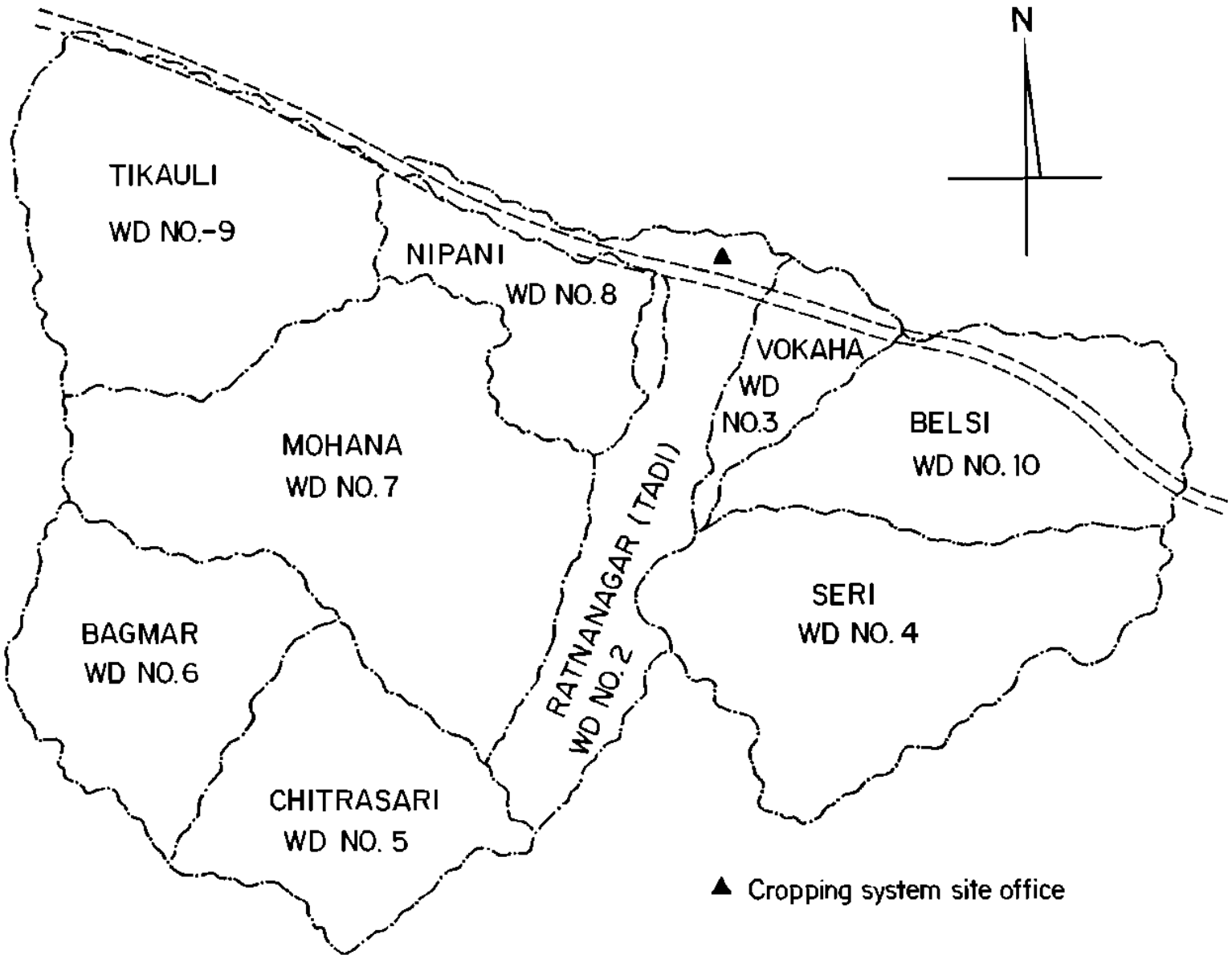

Fig. 2. Ratnanagar village Panchayet

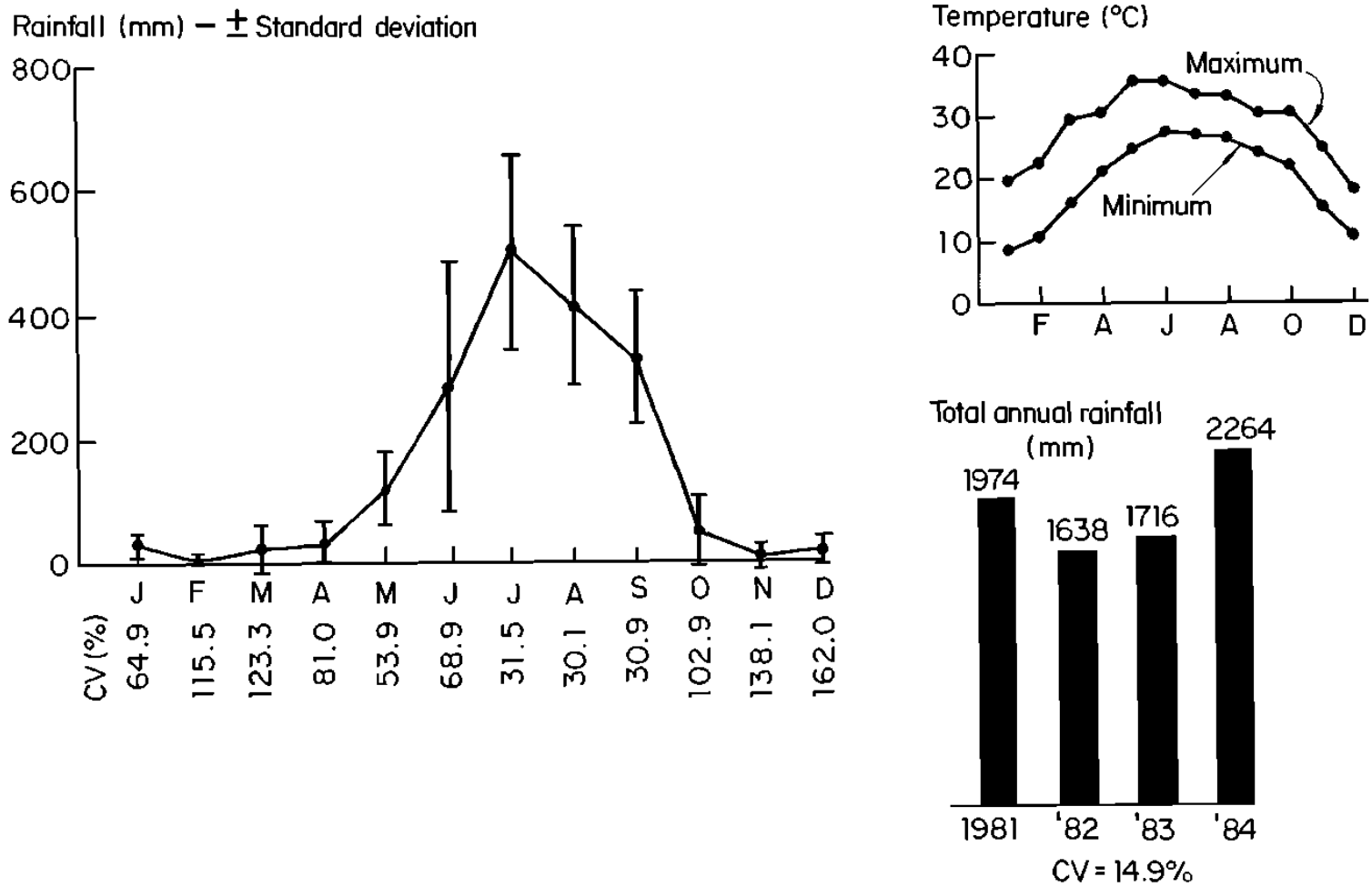

Fig. 3. Monthly rainfall and temperature means from September, 1980 to December, 1984, Ratnanagar, Nepal.

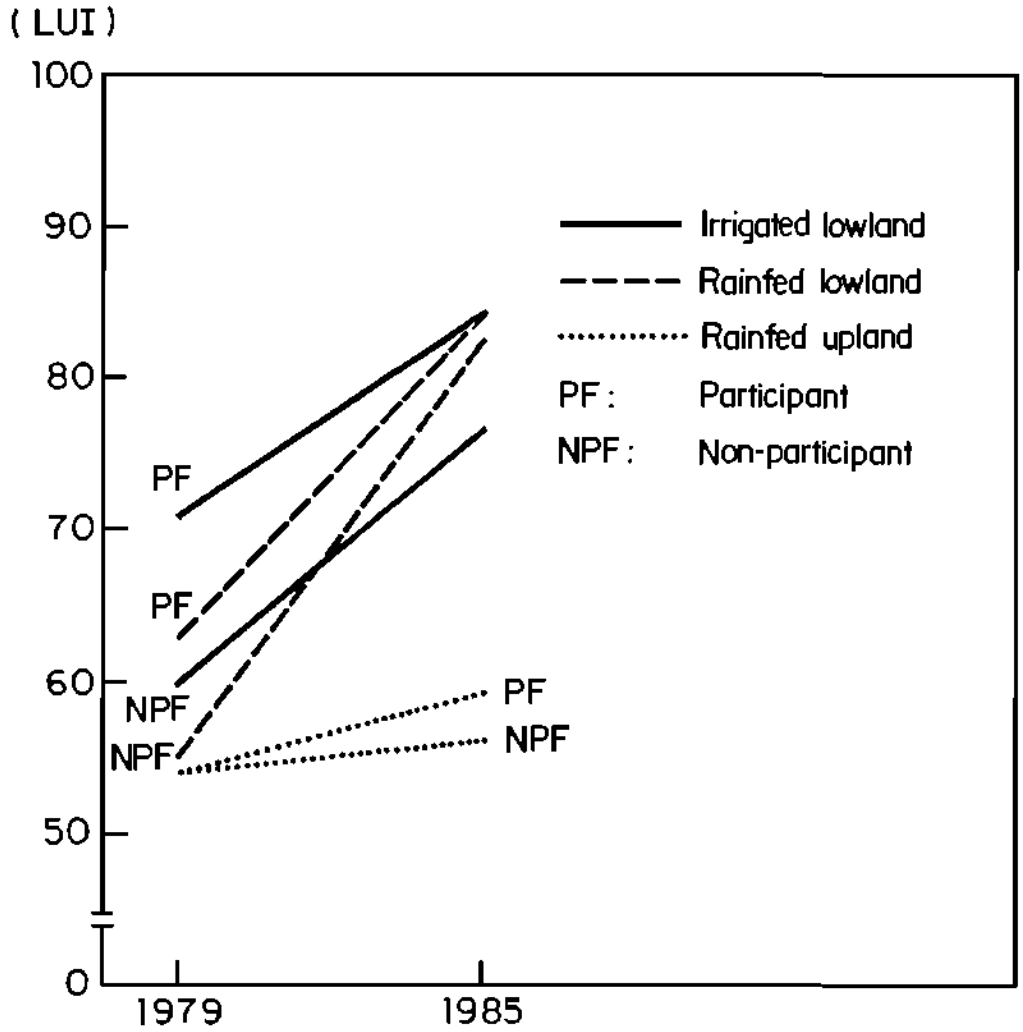

Fig. 4. Changes in land utilization index (LUI), Ratnanagar, Nepal.

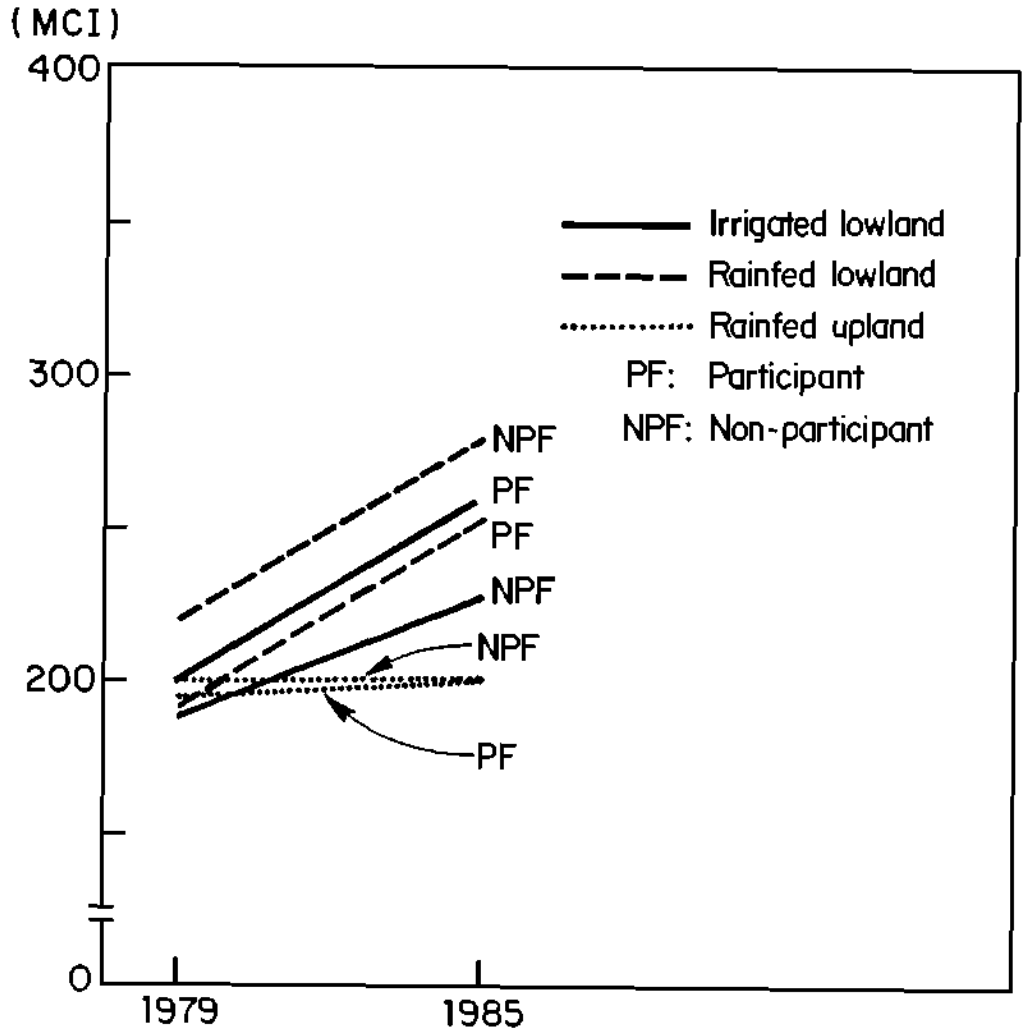

Fig. 5. Changes in multple cropping index (MCI), Ratnanagar, Nepal.

Intérêt de l'analse des systèmes d'exploitation pour la coherence des actions de développement agricole: Estude de quelques cas en region méditerranéenne

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L'équipe du laboratoire travaille depuis plusieurs années sur des programmes de recherche-développement dans certaines zones du sud de la France et de l'Algérie.

Ces travaux sont conduits selon la conception de l'analyse systémique préalable à la mise en place des actions de développement (OSTY P.L.,1978, BOURGEOIS A.,1983, TOURTE R.,1983, TREBUIL G. et coll.,1983, VISSAC B.,1983, FAYE J.,1985) très voisine de la conception anglosaxonne de "FARMING SYSTEM RESEARCH" (ZANDSTRA H.G.,1979, HARRINGTON L.,1980, MARTINEZ J-C.,1984). La méthode consiste à faire une enquête auprès des exploitants sur le fonctionnement de leur système d'exploitation et ainsi établir une typologie de ces systèmes, puis â mettre en place chez des agriculteurs représentatifs une expérimentation technique pour confronter les premières propositions à la réalité. Ces propositions sont alors précisées et complétées dans le cadre d'un dialogue permanent agriculteur-technicien.

L'objet de cette note est de présenter la démarche suivie et de montrer sur quelques cas l'intérêt de l'analyse en terme de système d'exploitation pour garantir la coherence des propositions avec la complexité de la situation des exploitations et de leur environnement physique ou social.

1) METHODOLOGIE DE RECHERCHE-DEVELOPPEMENT UTILISEE.

Dans notre démarche l'exploitation est appréhendée comme un système, selon la définition de De Rosnay : "un système est un ensemble d'éléments en interaction dynamique, organisés en fonction d'un but" (De ROSNAY J., 1975), et non comme une série de facteurs ou d'éléments indépendants.

Cette notion appliquée à l'exploitation agricole permet d'aborder celle-ci comme un ensemble d'acteurs (famille, salariés), et de facteurs productifs (foncier, cheptel mort et vif ...) avec leurs caractéristiques propres, leurs multiples interactions et leur organisation productive.

L'approche systémique, par un travail pluridisciplinaire, considère avec autant d'intérêt la description des différents constituants de l'ensemble que leurs niveaux d'organisation et leurs multiples relations (VISSAC B., HENTGEN A., 1979). On peut finalement définir le terme de système d'exploitation par le système constitué de l'ensemble des aspects structurels et fonctionnels de l'exploitation agricole.

L'analyse de ce système repose sur l'étude des relations de ces différents éléments au sein de l'exploitation et sur celles établies entre ces éléments et leur "environnement", ce terme étant pris dans son sens le plus large. Ces relations se situent à plusieurs niveaux délimités par des "frontières" plus ou moins nettes. La première suit les limites de l'exploitation et délimite le champ d'action direct de l'agriculteur, seul maître du pouvoir de décision. La deuxième englobe l'exploitation et son environnement immédiat avec lequel les échanges sont nombreux et fréquents, une action sur le domaine ainsi défini relève de la volonté commune de plusieurs partenaires dont l'exploitant lui-même. La troisième définit un ensemble plus vaste sans unité d'espace mais qui contient tout les facteurs lointains qui influent sur l'organisation et le fonctionnement de 1 exploitation; le pouvoir d'intervention de l'exploitant dans ce domaine est très réduit voire nul.

Les domaines de recherche, des études présentées ici, comprennent aussi bien des zones agro-climatiques homogènes (zones céréalières de 1 Algérie, Bassin de Ceret, collines méditerranéennes), que des groupes socio-professionnels (éleveurs ovins de la Plaine du Roussillon).

La méthode que nous avons suivie, lors de nos différentes interventions, comprend plusieurs étapes.

La première phase est axée sur une enquête auprès de l'ensemble des exploitants du secteur ou de la filière concerné. Cette enquête est un regard porté de l'extérieur sur les systèmes étudiés qui permet d'en préciser les grandes composantes et leur intégration dans leur environnement. Elle est conduite sous forme d'entretiens semi-directifs avec les exploitants qui expriment, révèlent, hiérarchisent et formulent leurs problèmes (30ISSEAU P., 1976). L'enquête par entretiens qui peut déjà être considérée comme une phase de développement, permet d'établir, en relation avec le sujet de l'étude, une typologie des systèmes rencontrés fondée sur les données structurelles des exploitations et les stratégies personnelles de développement des agriculteurs (MASSON Ph., 1976). Cette typologie permet de définir les domaines de recommandation et de diffusion de propositions de développement adaptées â chaque situation (BYERLEE D.et al., 1982. HILDEBRAND P.E., 1982, 1986). Cependant elle est insuffisante pour engager un processus d'aide effective, car elle ne précise pas le fonctionnement interne des exploitations.

Une deuxième phase plus technique intervient alors auprès d'un échantillon d'exploitants pris dans chacun des types préalablement identifiés. Cette phase a pour objet l'approfondissement par l'intérieur de la connaissance des systèmes, la progression avec les exploitants eux-mêmes dans la recherche des solutions adaptées à leurs problèmes, et la diffusion de ces solutions. Au cours de cette étape notre méthode consiste â proposer à l'agriculteur une "intervention", élément de réponse aux problèmes mis en évidence pendant l'enquête. Ce peut être l'expérimentation d'une technique existante ou à mettre au point, un suivi technique, une reflexion économique, etc.. Cette période "interventionniste" correspond aux actions qualifiées de "on farm research" par les centres de recherche internationaux, CIMMYT, IRRI notamment.

L'observation et l'analyse de l'adoption de cette "intervention", et des modifications qui en résultent sur le système d'exploitation, ou sur la formulation et la hiérarchie des problèmes, déterminent la suite du travail à mener par le technicien.

L'enquête avait permis de hiérarchiser les problèmes en fonction de leur importance et de leur priorité, l'intervention a pu confirmer cette hiérarchie ou la modifier selon le degré d'acceptation par les exploitants des contraintes liées â une technique ou une pratique nouvelle.

Dans le cas des études présentées, les suites de cette deuxième étape de l'analyse des systèmes d'exploitations sont différentes en fonction des premiers résultats enregistrés.

Dans certains cas la situation des agriculteurs limite l'adoption de techniques fondamentalement nouvelles, il faut alors prolonger l'étude de celles mises en oeuvre actuellement pour déceler les possibilités d'amélioration, afin d'assurer la continuité de l'action de développement engagée. Le travail se situe toujours dans les exploitations avec les exploitants.

Dans d'autres cas le besoin de techniques nouvelles apparaît, les agriculteurs sont demandeurs d'innovations, nous participons alors aux recherches de mise au point de celles-ci, cependant les contraintes de ces recherches ne sont pas toujours compatibles avec celles des exploitations aussi une partie du travail doit se réaliser en milieu controlé propice à la recherche agronomique.

2) LA COHERENCE ENTRE LES PROPOSITIONS ET LES STRUCTURES JURIDIQUES ET POLITIQUES D'EXPLOITATION : LE CAS DE LA PRODUCTION CEREALIERE ALGERIENNE.

Etudiant les blocages à la production céréalière en ALGERIE dans le cadre d'un travail avec le CI.M.M.Y.T. et le Ministère de l'Agriculture Algérien, nous avons du remettre en cause à la suite d'une analyse approfondie des systèmes de production, le principe couramment admis dans le pays selon lequel le principal facteur des faibles rendements était la concurrence des adventices.

En effet une vingtaine d'essais agronomiques sur blé également répartis entre des unités de production du secteur socialiste (Domaines, Coopératives) et des exploitations du secteur privé (petits Fellahs) ont donnés les résultats consignés dans le tableau 1. Le facteur desherbage était inclus dans des essais factoriels á 2 niveaux : pas de deaherbage et desherbage chimique mixte antigraminées (au Diclofop-methyl) et antidicotylédones (au 2—4-D).

Tableau 1 EFFET DU FACTEUR DESHERBAGE CHIMIQUE SELON LE SECTEUR DE PRODUCTION 1979-1980

SECTEUR DE PRODUCTION	SUPPLEMENT DE RENDEMENT OBTENU
SECTEUR SOCIALISTE	4.0 Qx./ha (significatif à P=* 0,01)
SECTEUR PRIVE	0.6 Qx./ha (non signifi. à P= 0,05)

On constate donc que le facteur desherbage chimique n'a aucun effet significatif en secteur privé alors qu'il donne un supplément de rendement important (de l'ordre de 20 X) en secteur socialiste.

L'étude du fonctionnement des exploitations du secteur privé nous a permis d'expliquer ces differences (MASSON Ph.,PETIT M.,1983). Les conditions de production des petits fellahs sont difficiles : petites surfaces, sols marginaux ou situation de coteaux, absence de matériel, isolement par rapport aux structures d'approvisionnement ou de conseil.

Les rendements en blé sont faibles de 5 á 10 quintaux par hectare. Les céréales sont gardées essentiellement pour 1'autoconsommation. Par ailleurs le prix du blé est réglementé et il n'y a pas de marché parrallèle. Par contre l'élevage ovin est beaucoup plus rémunérateur. Le prix du mouton est libre, il est élevé en raison d'une forte demande liée à l'augmentation du niveau de vie, et â des considérations religieuses.

Dans ces conditions, l'élevage ovin devient prioritaire sur l'exploitation. Le système de production adopté est : céréales/jachère pâturée par le troupeau. La jachère est labourée le plus tard possible pour laisser pâturer les ovins. La récolte du blé est attendue avec impatience pour laisser les chaumes aux moutons. Les chaumes et la jachère sont donc surpaturés par le troupeau, qui élimine pratiquement toute végétation adventice pour le blé. Par ailleurs les fellahs privés utilisent des variétés traditionnelles de blé à paille longue qui concurrencent mieux les adventices que les variétés modernes à paille courte utilisées surtout par les domaines.

Par contre sur les grandes unités du secteur socialiste la faiblesse de l'élevage et la pression faite par l'état pour remplacer la jachère par des cultures fourragères de vesce-avoine souvent mal préparées et récoltées trop tard ont entraîné une infestation croissante en adventices comme la folle-avoine justiciable d'un desherbage chimique.

Cet exemple montre bien qu'un facteur apparamment très technique comme le desherbage chimique peut être lié en fait à l'ensemble du système d'exploitation et notamment dans notre exemple aux structures juridiques ou politiques de production.

La suite du travail a montré l'importance du facteur fertilisation dans la production de blé en secteur privé. Une fertilisation raisonnêe en fonction de la pluviométrie et de la valeur du sol donnait des suppléments de rendements allant jusqu'à 6 quintaux de blé avec une rentabilité élevée. L'effet de la fertilisation était moins net en secteur socialiste où cette pratique assez courante avait remonté le niveau de fertilité des sols.

3. LA COHERENCE DES PROPOSITIONS AVEC LES CONDITIONS CULTURELLES DE LA PRODUCTION AGRICOLE : LE CAS DE LA PRODUCTION DE CERISES PRECOCES A CERET (FRANCE).

Le bassin de Ceret au sud de la France se caractérise par un hiver frais et un réchauffement rapide au Printemps qui permettent de produire les premières cerises de France. Cependant la production est irrêgulière en quantité et en précocité et progressivement les agriculteurs à plein temps se sont détournés de la production de cerises, trop aléatoire. Les cerisiers sont donc actuellement cultivés sur de petites surfaces par double-actifs (artisans, commerçants, fonctionnaires ou retraités) qui consacrent leurs loisirs à cette activité.

Nous sommes en présence d'un véritable système "cêrêtan" de la culture du cerisier (I.U.T. PERPIGNAN 1983) qui est le système dominant, les autres agriculteurs accordant peu d'importance au cerisier. Ce système a sa cohérence. La motivation est essentiellement culturelle : attachement à la production de la cerise qui est l'image de Ceret. Le marché de la cerise est une véritable institution qui â l'époque de son fonctionnement en Mai et Juin retient l'attention de toute la population qui suit les cours de la cerise.

Cet attachement culturel â la cerise entraine la conservation d'un système traditionnel de conduite de la culture tel qu'il a toujours été pratiqué: arbres de plein vent de grande taille, variété classique hatif Burlat,faiblesse des interventions culturales (peu de fertilisation et de travaux du sol, pas de traitement ni d'irrigation).

Cet attachement au cerisier se double et se confond avec un grand attachement â la propriété foncière héritée, soigneusement conservée, entretenue, léguée aux enfants qui à leur retraite s'occuperont à leur tour du verger, perpétuant la tradition et reproduisant le système.

Le problème essentiel de cette conduite du verger est le temps de travail pour la récolte qui est un facteur de coût croissant : 5 FF par Kg en 1983. Lorsque le prix de marché descendait à 7 FF la cerise n'était plus cuellie. La production a donc tendance à baisser d'année en année.

Comment baisser ce coût de cueillette? On connaît des techniques qui permettent de réduire par 2 ou 3 le temps de cueillette. Il s'agit de conduire le cerisier sous forme de haie frutière irriguée â haute densité. De nombreuses tailles d'été permettent de maintenir la forme et de tenir la fructification près de l'axe. La récolte reste manuelle mais se fait à partir d'une plateforme frutière et le rendement du cueilleur peut atteindre 150 Kg par jour au lieu de 50 Kg avec les formes classiques.

Quelle est la réponse des agriculteurs de type "cérétan" lorsqu'on leur propose de telles techniques? La réponse est simple: ce n'est pas possible! Qui s'étonnerait d'une telle réponse?

Tout en effet dans la haie fruitière est opposé au système cérétan : investissements importants (nombre élevé de plants â l'hectare, irrigation, plateforme fruitière), nécessité de grandes parcelles, travail important pour les tailles d'été incompatible avec la double activité, rupture avec la tradition du verger plein vent.

Si cette proposition est techniquement réalisable â Céret, elle est impossible à mettre en oeuvre dans les conditions du système cérétan. Elle n'est pas cohérente avec ce système et elle est donc rejetée ou plutôt inconcevable.

La présentation de cette approche d'un problème de développement par l'analyse des systèmes d'exploitation, a pour but de montrer la diversité des facteurs à prendre en compte dans une telle opération. Dans la région de Ceret, le facteur culturel attaché à la production de cerise l'emporte sur tout les autres, notamment l'économique, et conditionne toute évolution technique.

Les conclusions de ce travail ont été transmises aux responsables du développement de cette région, soucieux du maintien de la production de cerises.

4) LA COHERENCE DES PROPOSITIONS AVEC DES TECHNIQUES PASTORALES : LE CAS DE L'ELEVAGE OVIN DE LA PLAINE DU ROUSSILLON (FRANCE).

La plaine du Roussillon â l'extrême sud de la France est une petite région fertile, d'agriculture intensive à base d'horticulture, d'arboriculture et de viticulture. Cependant un élevage traditionnel de moutons s'est maintenu dans cet espace assez peu favorable à l'élevage, il est confronté â de nombreuses difficultés économiques, techniques, sociales qui hypothèquent son avenir (ROCHON JJ.,1981). Le nombre d'élevages diminue régulièrement.

Historiquement, la plupart des troupeaux étaient des troupeaux de montagne venus passer l'hiver en plaine dans des "mas" auxquels ils laissaient le fumier en échange des pâturages et de la paille.

L'élevage ovin constituait une activité secondaire, mais indispensable des exploitations, la dent des brebis assurant la lutte contre les mauvaises herbes, et le fumier étant le seul fertilisant disponible. Peu ou pas de surfaces cultivables lui étaient réservées , les troupeaux parcouraient les landes, jachères et chaumes et y trouvaient la totalité de leur alimentation.

Le système d'élevage ovin actuel est â la fois le reflet de ce système traditionnel et de son adaptation aux exigences modernes de productivité de l'élevage ovin français.

La finalité des troupeaux n'est plus le fumier ou la laine mais une production de viande conforme à la demande locale d'agneaux jeunes. Ces agneaux issus pour la plupart d'agnelages d'automne et élevés en bergerie sont abattus non sevrés, â un poids vif de 25 à 30 kg, et commercialisés sur le marché de Perpignan. Les principales périodes de mise â la vente sont Janvier, Février, Mars.

Les troupeaux appartiennent â des éleveurs sans assise foncière qui ont recours à des modes de location précaires des vignes et des friches. Cette situation de dépendance, voire d'infériorité, vis â vis des propriétaires fonciers et des agriculteurs, place les éleveurs dans un contexte socialement pénible. Les relations entre éleveurs et agriculteurs sont actuellement déséquilibrée : le troupeau a perdu son role dans le maintien de la fertilité des sols, mais reste demandeur de pâturage.

De plus la modification des techniques culturales perturbe la conduite des troupeaux : l'arrachage du vignoble et son remplacement par des vergers, le desherbage chimique des vignobles réduisent l'étendue des parcours. Les éleveurs dont les troupeaux doivent, pour des raisons économiques, augmenter se trouvent confrontés â des problèmes fourragers liés à la diminution de leurs surfaces de pâturage, â des difficultés de déplacement dans un espace de plus en plus morcelé, et à la pauvreté d'une végétation spontanée dont la production est très irrêgulière.

Nous avons étudié avec précision le mode d'exploitation des parcours constitués par les vignes, seul recours possible pour le pâturage en hiver. Il ressort de cette étude que l'utilisation des parcours relève de la simple "cueillette". Le viticulteur reste maître du mode de conduite de la vigne, et de son utilisation par les éleveurs. Caractéristique classique des systèmes pastoraux (LHOSTE Ph.,1984) les parcours sont extérieurs au domaine délimité par la première "frontière" du système d'exploitation.

La productivité fourragère des vignes soumise â un climat de type méditerranéen très contrasté est très irrégulière. Pour garantir l'alimentation des troupeaux même pendant les années sèches, les éleveurs cherchent à disposer de très vastes superficies de parcours (2 à 3 hectares par brebis), pour lesquelles ils n'acceptent de ne payer que de faible sommes en guise de droits de pacage.

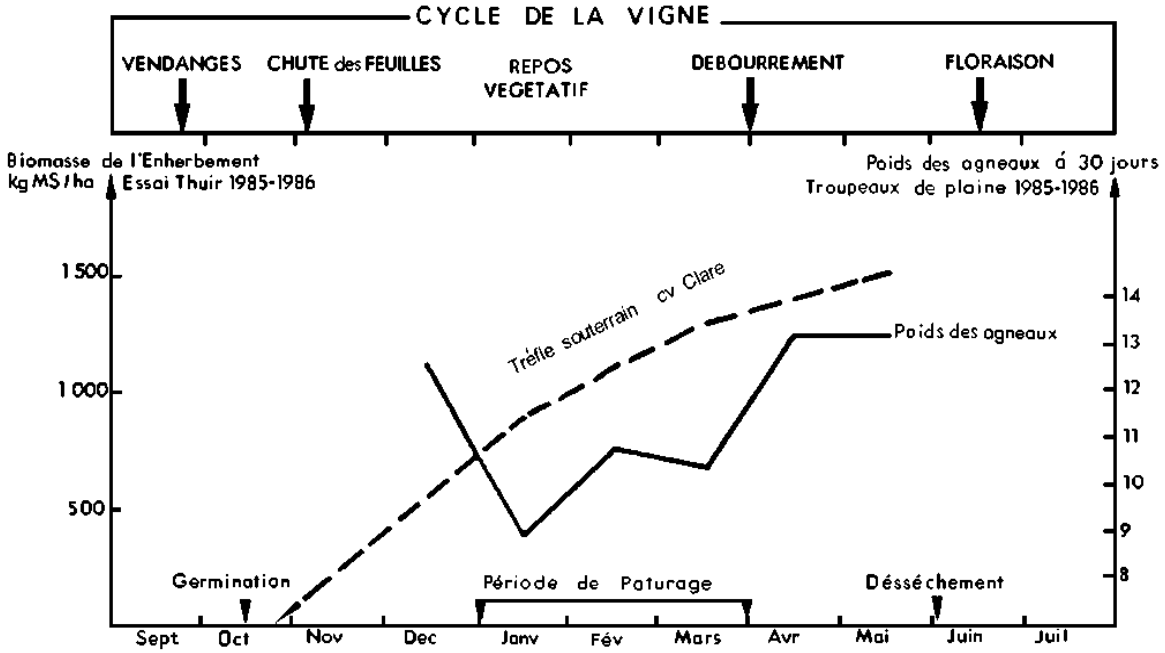
Les problèmes alimentaires du troupeau se posent principalement à la fin de l'hiver. Les réserves fourragères touchent à leur fin alors que les besoins des animaux augmentent avec les agnelages et les allaitements. Le niveau de couverture des besoins alimentaires des brebis est estimé par la croissance de leurs agneaux. Un indicateur intéressant est le poids des agneaux à 30 jours. Un suivi technique de troupeaux a montré que ce poid était minimum pour les naissances de Janvier, Février Mars (de 9 à 10 kg au lieu de 12 à 13 kg pour les autres mois). La quantité et la valeur fourragèr de la biomasse présente sur les parcours sont très faibles â cette période.

Il était donc interessant d'essayer d'augmenter la productivité de ces parcours. Mais l'éleveur ne possédant pas les vignes il fallait trouver une technique qui présente un intérêt également pour le viticulteur : nous avons donc envisagé un enherbement avec une plante fourragère à croissance hivernale, le trèfle souterrain (MASSON Ph.,ROCHON J.J.,1986). Les variétés précoces de ce trèfle terminent leur végétation en Mai de façon â ne pas faire de concurrence â la vigne pour l'eau pendant l'été.

Nous avons expérimenté cette technique dans un vignoble pâturé par un troupeau. Les résultats de production fourragère sont positifs, ainsi que la compatibilité Je l'enherbement avec les exigences de la vigne.

Graphique 1:

COMPATIBILITE DE L'ENHERBEMENT DU VIGNOBLE AVEC LE CYCLE DE LA VIGNE ET LES BESOINS DE L'ELEVAGE OVIN DANS LA PLAINE DU ROUSSILLON



Le viticulteur soucieux de la conservation Je ses sols est intéressé par l'enherbement qui assure une protection du sol contre les risques d'érosion, et augmente à terme le taux de matière organique améliorant ainsi les propriétés physiques, chimiques et biologiques du sol.

Pour l'éleveur la période de production de fourrage par l'enherbement correspond exactement au moment où les performances du troupeau déclinent en raison d'une alimentation insuffisante. Pendant cette période la vigne enherbée peut fournir à des femelles en lactation environ 750 journées de pâturage par brebis et par hectare, alors que les vignes non enherbées n'en offrent au mieux que la moitié.

L'enherbement Jes vignes avec un trèfle souterrain précoce est une technique qui concilia l'intérêt des Jeux utilisateurs du même espace ; cependant l'éleveur n'ayant pas la maîtrise du foncier il faut que la culture soit mise en place par le viticulteur qui y trouve un intérêt. Cependant, malgré l'amélioration de la conduite du troupeau par la réduction des déplacements, et l'alimentation des animaux pendant une période critique avec un fourrage de qualité, les conditions d'exploitation du vignoble restent inchangées, l'enherbement ne restitue pas au troupeau sa place dans le système de production du viticulteur.

En effet cette amélioration du système de production est indépendante de l'éleveur; elle est soumise â la volonté des viticulteurs, l'éleveur a une attitude passive et attentiste.

En second lieu, les délais de diffusion de cette technique sont longs car elle remet en cause des habitudes fortement implantées chez les viticulteurs. Cette attente de l'extension de l'enherbement ne lui permet pas de répondre aux besoins de développement immédiats de l'élevage ovin. Le coût d'installation de l'enherbement, relativement élevé, est actuellement â la charge du viticulteur seul. Ce coût ne favorise pas l'extension rapide de l'enherbement, d'autant que les viticulteurs ne peuvent pour l'instant faire partager cette charge par les éleveurs bénéficiaires de ces pâturages. En effet bien que les vignes enherbées sont des pâturages productifs et de qualité, pour les éleveurs ils restent des parcours auxquels sont attachés les deux caractères fondamentaux : l'espace et le faible coût d'utilisation.

Des essais répétés doivent démontrer la régularité et l'importance de la production fourragère afin de montrer aux éleveurs la fiabilité de cette technique. Une fois cette confiance établie, les vignes enherbées ne seront peut-être plus perçues comme des parcours et le comportement des éleveurs à leur égard pourra changer. En particulier ils pourront se contenter de ne maîtriser que des surfaces réduites et accepter de payer des droits de pacages plus élevés. Des relations nouvelles s'établiront entre le viticulteur et l'éleveur fondées sur un échange monétaire important, réellement intéressant pour le viticulteur, et plaçant l'éleveur dans la situation d'acheteur d'un bien produit et non plus de pasteur utilisant une ressource spontanée. Cet évolution des relations améliorerait le statut social dé l'éleveur.

Afin d'assurer la permanence de notre action, pendant la période de diffusion de l'enherbement, nous avons poursuivi l'analyse de ces systèmes de production pour mettre en évidence des actions plus rapides à mettre en oeuvre

+ rationnalisation de la production d'agneaux, par le controle de la reproduction et du mode d'élevage,

+ recherche, et diffusion d'indicateurs facilement perceptibles par les éleveurs, pour contrôler l'état des animaux.

5) LA COHERENCE DES PROPOSITIONS AVEC LE RESPECT DE L'ENVIRONNEMENT DANS LES ZONES SENSIBLES : LE CAS DES COLLINES MEDITERRANEENS DU SUD DE LA FRANCE.

L'Aspre et le Fenouillèdes représentent Jeux petites régions situées dans un ensemble géographique beaucoup plus vaste : La Basse Montagne Méditerranéenne. Situées entre 200m. et 600 m. d'altitude, ce sont des zones qui depuis l'Antiquité ont toujours été utilisées. L'entretien et la protection de ces régions étaient assurées par la présence d'une population importante.

Aujourd'hui, elles sont assimilées â des zones pauvres, sèches, désertifiées, très peu productives. Leur dégradation est humaine (dépeuplement et abandon des activités économiques, notamment agricole se poursuivent depuis le début du siècle), et physique (érosion des sols, régression végétale, dégradation climatique et hydrique). A ces phénomènes d'abandon vient s'ajouter l'action des incendies répétés brûlant chaque année le maquis qui a recouvert ces régions depuis un demi-siècle.

Les fonctions remplies par ces zones de basses collines, en situation d'arrière-pays par rapport â la Plaine du Roussillon sont essentiellement sociales (loisirs, chasse, résidence secondaire). Une fonction économique réduite subsiste â partir de la foret, et de l'agriculture.

La protection de ces régions n'est plus assurée par ses habitants, mais est à la charge de la collectivité. Un moyen de réduire cette charge est d'augmenter le role productif de ces espaces dégradés qui diminuera la combustibilité du couvert végétal et modifiera le comportement Jes hommes.

L'activité agricole, pratiquée dans ces zones difficile, est variée à base d'élevage ou de viticulture (BARELLO A.1983). Il nous était demandé de voir si ces formes d'agriculture pouvaient contribuer â l'entretien et à la protection du milieu.

A la suite d'une enquête exhaustive nous avons pu établir une typologie des exploitations par rapport à leur impact sur le milieu (I.U.T PERPIGNAN 1984).Nous avons pu mettre en évidence quatre grands groupes d'agriculteurs :

-le type INTENSIF correspond à une valorisation forte du sol très protectrice du milieu mais sur un espace limité. Ce sont des viticulteurs ou des arboriculteurs qui ont réduit la surface cultivable de leur exploitation aux zones mécanisables et ont totalement abandonné le reste qui retourne au maquis. La viticulture de qualité permet de tirer un bon parti des caractéristiques du milieu, de procurer un revenu correct mais ne permet pas une protection complète du milieu car elle ne peut se pratiquer que sur une faible portion de l'espace.

-le type UTILISATEUR correspond à une utilisation de l'espace qui se rapproche de la cueillette sans aucun souci de gestion et de protection de la part de l'exploitant. Ce sont des éleveurs traditionnels d'ovins ou de caprin qui gardent leurs troupeaux sur des parcours qui se dégradent d'année en année par absence de gestion. Il y a très peu de cultures fourragères et les achat de foin et de céréales mettent en péril la rentabilité des exploitations.

-le type VALORISATEUR met réellement en valeur un espace important par un élevage bovin ou caprin certes extensif mais soucieux j'amelioration pastorale et fourragère. Il s'agit le plus souvent d'éleveurs jeunes, innovants, dynamiques, à la recherche Je nouvelles techniques d'élevage à base d'animaux rustiques en plein air intégral, de création de parcs clôturés et débroussaillés, de remise en culture de friches pour créer des cultures fourragères. Ces éleveurs contribuent à redonner à ces régions une image de renouveau économique mais ils ont des problèmes techniques et fonciers qu'il faut prendre en compte pour conforter leur exploitation.

-un type HORS.SOL constitué d'élevages hors sol de lapins ou volailles sans aucun impact sur le milieu si ce n'est indirectement par la présence de population qu'ils permettent. L'espace constitue leur cadre de vie.

Les agriculteurs appartenant aux types Utilisateur et Valorisateur ont une action directe de grande envergure sur le milieu naturel par l'intermédiaire de leurs troupeaux. Parmi eux les Valorisateurs apportent une contribution durable à l'exploitation et la protection de l'espace.

Le développement Jes exploitations de ce type est soumis à la mise au point de systèmes Je production nouveaux pour cette région française.

Un exemple J'utilisation Je milieux semblables â ces basses collines nous est fournie par la DEHESA espagnole. Sous un couvert forestier faible (50 arbres/ha) une prairie est implantée, et fournit un pâturage qui permet une charge animale suffisante pour contrôler la croissance de la végétation arbustive. Les systèmes d'élevage reposent sur une complémentarité entre des productions fourragères intensives et des techniques pastorales.

En collaboration avec les organismes de développement spécialisés dans l'élevage et les cultures fourragères, nous avons mis en place un programme d'étude sur les fourrages méditerranéens susceptibles d'améliorer les ressources fourragères Jans ces milieux.

Ce programme est basé sur l'introduction d'espèces fourragères peu connues en France, résistantes â la sécheresse et adaptées aux sols acides des collines : nous avons travaillé essntiellement sur le trèfle souterrain (Trifolium.subterraneum), les lupins (Lupinys albus. L. luteus),et sur certains arbustes fourragera tels que la luzerne arborescente (Medicago arbórea).

Le premier aspect de ce programme, l'installation de collections, est lié á la nouveauté de l'introduction de la plupart de ces espèces fourragères dans ces milieux difficiles. Ne possédant aucune référence fourragère sur la zone, il était capital d'obtenir des données précises. Il s'agit d'un travail classique de recherche effectué en milieu protégé et en microparcelles, sans collaboration avec les exploitants.

La deuxième étape consiste à mettre en place des essais chez les éleveurs, dans leurs propres conditions. L'objectif est de tester les fourrages sur des parcelles suffisamment grandes et d'obtenir des références significatives sur les conditions d'exploitation (Tableau 2).

Tableau 2 RENDEMENT DES PRAIRIES A TREFLE SOUTHERRAIN
Collines méditérranéennes des Pyrénées Orientales

LOCALISATION	VARIETE	PRODUCTION EN 2 ème ANNEE le 15/5/1986
CAIXAS (alt 250m)	CLARE	2,8 tonnes de MS/ha
	WOOGENELLUP	2,3 " "
CASEFABRE (ALT 400M)	CLARE	2,8 " "
	WOOGENELLUP	2,5 " "
	MT BARKER	2,3 " "
PRATS DE SOURNIA (alt 600m)	MT BARKER	2,2 " "
ST MARTIN L'ALBERE (alt 600m)	MT BARKER	2,0 " "

Ces Jeux étapes ont permis de montrer qu'une espèce comme le trèfle souterrain pouvait résister au froid (MASSON Ph. et coll.,1985), et donner des rendements en matière sèche de 2 à 3 tonnes par hectare, avec un cycle de production hivernal intéressant (MASSON Ph., GOBY JP.,1985).

Les exploitations de ces zones se caractérisent par de faibles surfaces cultivables en raison de la topographie ou des problèmes fonciers, et par des surfaces importantes de parcours. Nous engageons un travail sur le sursemis de parcours pauvres en espèces intéressantes.

L'enrichissement des parcours peut porter sur des surfaces importantes et avoir un impact élevé sur la protection de l'espace si l'augmentation de la charge animale permet l'entretien de ces surfaces. Nous avons entrepris en Octobre 1985 un premier essai de sursemis de trèfle souterrain et fétuque élevée dans une foret de chêne liège débroussaillée mécaniquement dans le cadre d'opérations en cours de renovation de la subéraie. Un léger piétinement des animaux a permis une bonne levée du semis avec des peuplements en première année analogues à ceux obtenus par semis avec travail du sol. Cet enrichissement du parcours doit permettre en couvert forestier lache de tendre vers un paysage analogue à la DEHESA espagnole.

Cet exemple montre comment l'analyse des systèmes d'exploitation peut contribuer â replacer l'agriculture dans son environnement, et permettre J identifier les techniques á développer aptes à assurer aux agriculteurs les moyens d'exercer leur profession, mais aussi capables d'avoir un effet bénéfique pour l'ensemble de la collectivité grace á une meilleure protection du milieu naturel.

CONCLUSION

Nous avons voulu illustrer par ces quelques exemples la diversité et la complexité des situations des exploitations agricoles. L'intérêt de l'analyse systémique est de prendre en compte l'ensemble des facteurs qui déterminent cette situations et de pouvoir mettre l'accent sur des aspects essentiels dans l'élaboration des techniques adaptêes et qu'il est facile d'oublier : aspects sociaux, juridiques, culturels.

Il résulte de cette diversitë une multiplicité des actions de dêveloppement agricole possibles.

Les deux phases de l'analyse des systèmes permettent la mise en évidence des besoins de développement des exploitations à long et court terme.

L'enquête sur les facteurs de production et leurs interactions situe l'exploitation dans son environnement proche et lointain; elle montre les points Je blocages existant ou à venir et détermine ainsi les actions à mener pour un dêveloppement durable.

La phase interventionniste est la mise en contact d'une proposition technique améliorante et des systèmes auxquels elle s'adresse. Elle donne la capacité de transformation des systèmes, et permet la reconnaissance des voies de dêveloppement à suivre par les techniciens et les exploitants.

Lorsque les besoins mis en évidence ne relèvent pas de techniques connues, l'approche du développement par l'analyse des systèmes d'exploitation peut apparaître comme la confrontation entre une problématique de développement et une problématique de recherche. La première qui est à l'origine de l'action engagée, donne naissance â la seconde. La problématique de recherche est une contribution du technicien à l'opération de développement. Ces deux problématiques sont indissociables et complémentaires.

Cependant au cours de l'action, lorsque la dynamlque du développement ne suit pas celle de la recherche, le technicien se trouve face â un dilemne : réorienter sa recherche pour poursuivre le développement, ou prêceder le développement en approfondissant la recherche. Les deux voies sont des suites directes de l'analyse et sont inévitables, elles montrent clairement la nécessité de la collaboration entre les techniciens de la recherche et ceux du développement. Les quelques cas présentés montrent que cette collaboration doit s'accompagner d'un dialogue permanent avec l'exploitant, afin d'assurer la continuité de l'action de développement, même lorsque les préoccupations quotidiennes de l'agriculteur prennent le pas sur l'objectif final.

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Linkage Experiences in a Farming Systems Research Program in Lesotho

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The degree of linkage that occurs from a Farming Systems Research Program varies not only among but within countries. In contrast to experiences in North Africa (O'Rourke and Goebel 1984), successful linkage has been more easily achieved in Lesotho. Countries of North Africa are generally diverse in languages and dialects as well as traditions while Lesotho is characterized by a relatively homogeneous population although diverse in climate and topography.

The Lesotho people are also characterized by a high degree of literacy. Good education is provided by various religious missions and government- sponsored schools at the primary level. In addition, higher education is provided at the University of Roma and Lesotho Agricultural College at Maseru.

Prototype Areas

Three prototypes have been established (Figure 1) in the major physiological regions in the Kingdom of Lesotho (Goebel and Ramakhula 1985). In general, the lowlands range in elevation from 1400-1750m. This region is predominately subhumid with warm summers and cold winters. Dominant vegetation includes red grass (*Themeda trianda*), turpentine grass (*Cymbopogon plurinodis*), lovegrass (*Eragrostis spp*.), and thatchgrass (*Hyparrhenia hirta*). These grasses, when mismanaged, are often replaced by "sehalahala" (*Chrysocoma tenuifolia*), which can cause poisoning in young animals (Goebel et al. 1986).

The foothills range in elevation from 1750-2000m. In addition to the species abundant in the lowlands "letseri" (*Festuca caprina*) is common on the south slopes. Buckthorn shrubs (*Rhus spp*.) may also dominate as well as *C tenuifolia.*

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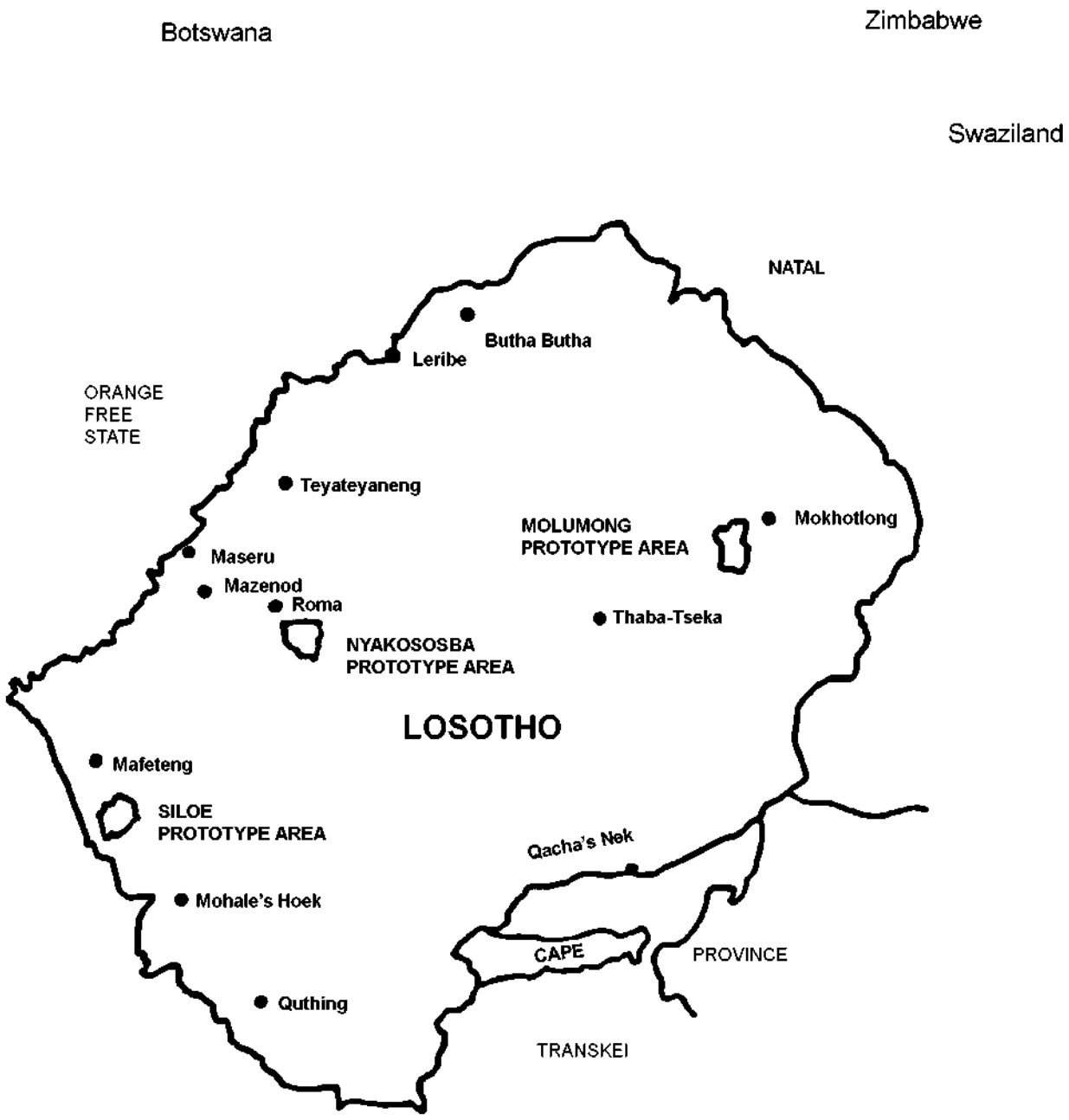

Figure 1. General map of Lesotho emphasizing prototype areas of Siloe, Nyekosaba and Molumong and vicinity (Adapted from Dobb, 1985).

The mountain regions range from 2000-3484m. The mountainous vegetation is dominated by cool-season grasses including "moseha" (Merxmuellera disticha), "letseri" and "mosea" (M. drakensbergensis) in seepage areas.

Lesotho is unusual in comparison to land uses in other countries of southern Africa and of the world. Percentage of arable land is approximately 12 percent and subject to intensive gully and sheet erosion. The percentage of grasslands remain about 80 percent (Goebel 1985, Tainton 1981) although some of these steep lands are cultivated temporarily and then returned to range. This high percentage is in sharp contrast to the average of 47 percent range lands characteristic of other countries of the world (Stoddart et al. 1965). Thus, Lesotho has a predominately range setting.

Agriculture, and in particular, domestic animals and their products are important economic assets to Lesotho (Klosterman 1984). The Bureau of Statistic's current sources report that Lesotho supports over one-half million cattle, one and one-half million sheep, one million goats and approximately 245,000 horses and donkeys. In addition, livestock holds a special place in the heart of every Mosotho (citizen of Lesotho). It is exemplified that 97 percent of all households with land have animals (Goebel 1984).

Positive Linkage

Physically and sociologically there have been encouraging results from the linkage of on-station Farming Systems Research introduction trials to field trials and extension activities. An example may illustrate this linkage.

A number of fodder sorghums were introduced into the cultivated fields at the Maseru headquarters of the Farming Systems Research Project (Goebel 1985). Initial introductory trials were begun at Maseru because greater control from

theft and trespass grazing was possible. In addition, daily measurements and observations were possible. After characteristics such as drought resistance, time of phenology and dry-weight production were determined, appropriate cultivars were selected for various field trials on farmer's fields on the Siloe Prototype. This area is situated in the eastern-central portion of Lesotho. Although receiving an average of 450 mm of precipitation annually, the potential evaporation is over 2000 mm per year.

The Molumong prototype area, in comparison to the Siloe lowlands, also lies within a rain-shadow. However, moisture that is received at Molumong is more effective than Siloe because of the lower evaporation rate. This mountainous prototype, however, is frequently subject to late and early frost damage to its maize crop. When informed about the extensive fodder sorghum trials at Siloe many farmers from the Molumong prototype expressed interest in paying for their own way to visit the Siloe farmers and observe their practices. This is one of the highest compliments, we feel, that can be paid to the success of a program when poor farmers are willing to pay for a field trip to another site 460 kilometers away. Finally, a total of eight farmers from the Molumong District did visit Siloe and became interested and adopted many of the agricultural practices. The crux of the linkage is that the Siloe farmers then became interested enough that they want to arrange a field trip to the Molumong prototype to observe other fodder species that may be useable at Siloe.

A more general example of linkage success within Lesotho was brought about by changes occurring within the adjacent country of the Republic of South Africa. Approximately two-hundred thousand Basotho men are employed within the Republic while their wives and children tend the farms and herd livestock respectively. Overgrazing of Lesotho's pastures and rangelands was aggravated by a significant increase in miner's wages during the 1970's. This "extra"

money was brought back to Lesotho through the importation of large numbers ofcattle which are regarded by the Basotho as their "fluid bank account," to beused for weddings, school fee purchases and feasts. Imports in livestock,principally cattle, were significant (Table 1). Import numbers increased from 3,371 in 1973-74 to 55,369 and 41,998 during 1978 through 1980. Farming Systems Research personnel as well as other consultants suggested legislation that was adopted to limit imports except to improve genetic quality of herds or slaughter. By 1981-82 imports had dropped to 7,447. Exports over the same period decreased significantly (Table 1).

Table 1. Total cattle numbers and imports in Lesotho over the period of 1973 to 1983 (Anonymous 1984).

Year	Total Cattle	Imports	Exports
1973-74	465,500	3,371	9,646
1974-75	512,400	20,218	4,519
1975-76	502,400	28,681	1,690
1976-77	485,500	40,364	1,122
1977-78	526,181	53,853	649
1978-79	560,327	55,998	799
1979-80	593,929	41,998	730
1980-81	589,976	18,116	2,171
1981-82	562,372	7,447	2,460

A final example of a positive as well as some negative linkage occurred near the Nyakosaba prototype area (Goebel and Ramakhula, 1984). Eight farmers in the foothills volunteered to cooperate in a supplemental feeding trial with sheep and angora-type mohair goats. During the trial, there appeared a lack of interest from the farmers in improvements in the quality of mohair or wool.

national policy to subsidize breeding stock to improve quality. Evaluation of research results demonstrated that wool quality could be substantially improved (Tiedeman et al. 1983) but this major improvement in quality amounted to a minor increase in price for the wool. The marketing specialist on the FSR team went on to evaluate the price structure of mohair at the national level and found similar results (Wyeth 1984). An informal social survey was then conducted with the cooperating farmers which revealed a consistent attitude by the farmers that meat and the production of offspring not wool or mohair were the major incentives for raising small stock. This information was passed on to the Extension agents who readily accepted the information. However, government officials were interested in wool and mohair not meat, since tax revenues were collected from wool and mohair exports and not from domestically consumed meat.

An important negative response learned from this trial is the way research is conducted with farmers' animals. A few animals were randomly selected from each of the farmer's flock for the trial. These animals were then managed by researchers on station controlled rangeland. Since the Research Division managed the animals, an important linkage with the farmers was lost concerning management constraints faced by the farmers in applying the improved technology. A better alternative would be to include the farmer's entire flock along with his herd boy and associated management in the trial even though fewer farmers may become involved. Feedback from the farmer concerning the improved technology would improve the focus of research, identify acceptability of the new technology, and the information rapidly transferred to other neighboring farmers.

Negative Linkage

Unfortunately, there are also linkage experiences that are not as rewarding as one would desire. One, in particular, stands out as an example that hopefully can be avoided in future situations. It involved the planned termination of one particular field trial. The farmer had been given improved and tested seed from cultivars which were to be grown and contrasted with his commonly-used seed. During the middle of the growing season field inspection indicated wide differences between production and phenology. It had been agreed earlier that research personnel would obtain samples of each planting and the farmer would obtain the remainder of the crop. A week before final harvest was to occur this was, again, reaffirmed. However, when the day of sampling approached it was found that the entire crop had been harvested without any separation of seed sources. The farmer apologized and said that he had thought the research laborers were coming earlier. He went on to say that the weights could easily be obtained next year. The moral is "the greatest problem in communication is the illusion that it has been achieved."

This was not a biological but a sociological break-down in communication. This type of "communication gap" may be avoided in the future by holding periodic meetings with all participating farmers in the area to collectively explain the objectives of the program. It should also be spelled out as to the benefits and support that must be obtained from both the research personnel and the fanners. It is debatable if previous results should be discussed at such a meeting for fear that farmers may try and modify their own results to fit the normal. Finally, communication must be maintained for farmers to keep their part of the agreement.

A more general example of linkage failure is the recent decrease in quantity and quality of mohair production from the one-million angora goats in Lesotho. Wyeth (1984) postulates that "high yields per goats obtained in South Africa are not feasible under Lesotho's current range conditions, and the farmers are aware of it." Thus, although the initial recognition of overgrazing has been accomplished, the philosophy of more production from fewer animals has not been completely accepted.

Conclusion

The signs are clear that changes are occurring. Western dress, music and videos have been readily accepted by the people of Lesotho. Now, there are signs that conservation measures are being accepted and implemented. Optimism that these conservation measures will continue to be accepted is an essential ingredient for working in Lesotho or any developing country.

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The On-Farm Research Program for palawija based farming systems in Malang District, East Java, Indonesia, 1984-1986

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1.0 INTRODUCTION

This paper summarizes work conducted to date in on-farm research (OFR) by the Malang Research Institute for Food Crops (MARIF), located near Malang, East Java, Indonesia. MARIF is one of the Bix research institutes operating under the Central Research Institute for Food Crops (CRIFC), a dependancy of the Agency for Agricultural Research and Development (AARD), the Indonesian organization with responsibility for all agricultural research within the Ministry of Agriculture. MARIF's research mandate covers "palawija crops" (non-rice food crops) particularly maize, soybean, other grain legumes and cassava.

The MARIF OFR program was initiated in January 1984 in cooperation with the International Maize and Wheat ImprovementCenter (CIMMYT) and the ATA 272 Project of the Agricultural Technical Cooperation Program between Indonesia and The Netherlands. The interdisciplinary MARIF OFR team consists of plant breeders, crop protection specialists, agronomists and economists.

The MARIF OFR program has two major objectives : 1. Try out OFR procedures on a pilot basis in order to ascertain their appropriate role in MARIF activities, 2. Develop useful recommendations that farmers in a study area would rapidly adopt. Because of the pilot nature of the program, it was decided to initially restrict OFR activities to one relatively homogeneous study area in Malang district. As the program developed, OFR work has begun in other study areas as well. However, this report only discusses the original OFR pilot effort.

MARIF OFR activities in the study area to date include an initial exploratory survey, soil analysis, a formal production survey, additional surveys on specific issues, and five crop cycles of on-farm experiments. Currently a sixth cycle is being planned. With two cycles of experiments per year, research has been underway for about two and a half years. These activities have been described in detail in a series of nineteen working papers (see Annex 1).

The MARIF OFR program is based on the procedures for "on- farm research with a farming systems perspective (OFR/FSP)" developed by CIMMYT, documented in Byerlee, Collinson et al (1980) and numerous other publications. The major steps in these procedures are diagnosis, planning, experimentation, assessment and formulation of recommendations. The guiding principles of the OFR/FSP procedures are:

1. A careful focus on important problems and possible solutions
2. On-farm research under representative conditions
3. A focus on defined groups of farmers
4. Farming systems perspective
5. Near term solutions.
6. Participation of farmers and extension service

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7. Interdisciplinary co-operation among biological and social-scientists
8. Feed back between on-farm and on-station research.

This paper contains a description of the study area in Malang, followed by a summary of the diagnosis of farmers' circumstances, practices and problems. This is followed by a discussion of the evidence obtained from farm surveys and on-farm experiments regarding possible solutions to the more important problems. The paper concludes with an overview of the evolution of research themes and priorities.

2.0 DESCRIPTION OF THE STUDY AREA

The pilot study area is located in Malang district, E. Java province. The location of this district is shown in Figure 1.

Farmers in the Malang district operate reasonably complex farming systems, featuring intensive use of a small land resource base. Major groups of enterprises include livestock enterprises, annual crop enterprises, and home garden/perenniel crop enterprises. MARIF's research mandate is restricted to annual palawija crop enterprises. Where these interact with livestock and home garden enterprises, the fact will be noted in subsequent sections.

2.1 Crop production systems in the Malang district

The crop production systems in Malang district are heavily influenced by land type-sawah vs tegal. Sawah systems are dominated by wetland rice cultivation, although palawija crops ("secondary", non-rice food crops) are at times grown after rice. Tegal fields (unbunded, rainfed fields) are responsible for the bulk of palawija production. A summary of major systems is shown in Table 1.

For the initial pilot OFR program, the second system was chosen. This is a relatively simple system (the first, more complicated system was chosen for study during the expansion of the MARIF OFR program). Major characteristics of the selected system are: young volcanic soils; tegal land type; medium altitude; maize-maize or upland rice-maize cropping pattern. Maize is by far the most important enterprise in this crop production system.

The chosen system (henceforth referred to as the "study area" covers around 30,000 ha of physical area in Malang and includes an estimated 40,000 farms, each operating around 0.8 ha of tegal farmland (physical area). When extrapolated to other, similar districts of East Java, the area should cover 100,000 to 150,000 ha and would include up to 200,000 farms.

It should be noted that some farmers (about 28% of study area farmers) operate on both tegal and sawah. That is, they operate system 3 as well as system 2. This leads to certain

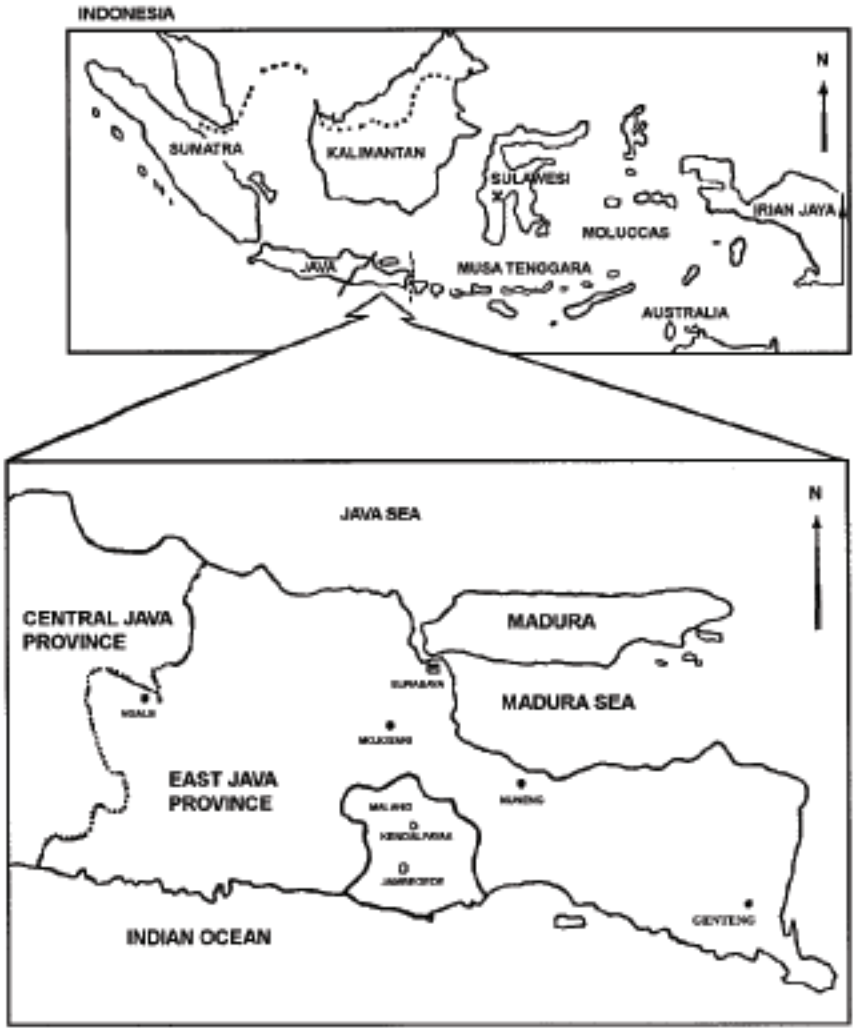
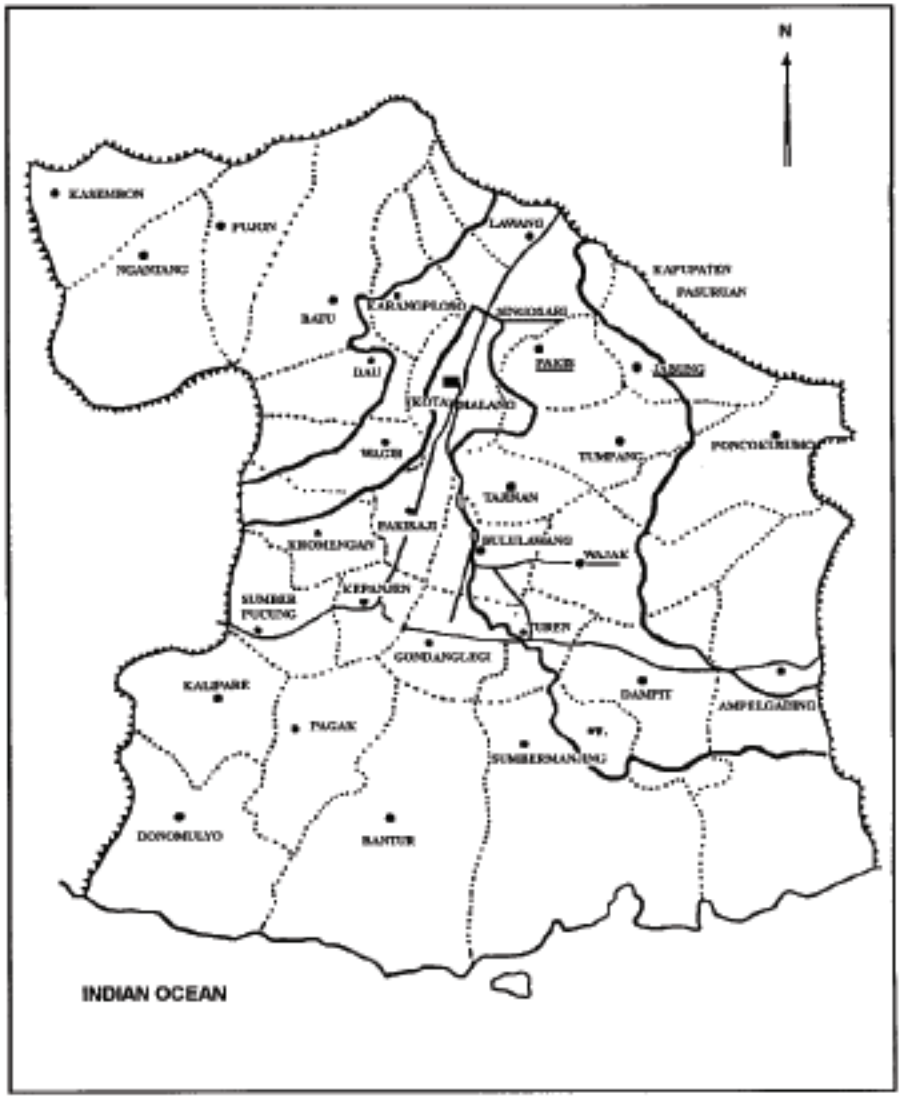


Figure 1. Map of Indonesia and East Java.



Maize production systems on tegal on young volcanic soils within the Malang district.

system interactions, including increased labor scarcity in the early stages of the first crop cycle, a lower dependence on maize as a starch staple, etc. In so far as they affect technology adoption, these interactions will be pointed out again where relevant in the sections on diagnosis.

Table 1. Major crop production systems in Malang district

System No.	Land type	Soils	Cropping Pattern	Altitude (+ meter)	Phys ical Area (X)
1.	tegal	limestone	cassava + (maize -legume)	< 600	43
2.	tegal	young volcanic	maize-maize	400-700	37
3.	sawah	alluvial & young volcanic	transplanted rice-maize	400-700	15
4.	tegal	young volcanic & volcanic ash	maize and horticul-tural crops	400-1500	5

Apart from this, the farmers in the study area confront reasonably similar circumstances, problems and opportunities and for most purposes (but not all) would likely use similar kinds of new technology.

2.2 Physical Conditions

Climate: The average rainfall in the study area amounts to 2130 mm per annum with 5 to 6 wet months (over 200 mm rain/month) and 2-4 dry months (less than 100 mm of rain/month). The average temperature is 24 centigrade with average minimum of 18.6 and maximum of 25.7 centigrade. The relative humidity ranges from 77 to 85 %. A monthly rainfall distribution is not shown here because of space limitations.

Soils: The main soil categories in the Malang district consist of: young volcanic soils (36 %), volcanic ash (18 %), limestone and lithosoils (37 %) and alluvial (9 %). The study area focuses on the young volcanic soilB which consist of latosols (60 X), regosols (26 %) and other soil types (14 %). All of these soils, including the latosols, are known to be generally deficient in organic material and in P, and are often

deficient in other plant nutrients (K, S, Mg, etc.) as well.

2.3 Economic Circumstances

There are a number of socio-economic circumstances that influence farmer decision-making in the Malang study area. Of interest are input markets, government price policy for inputs, marketing, and consumption patterns and taste preferences. Given the predominant position of maize in the crop production system, economic circumstances that affect maize are highlighted.

Input markets: Input markets in the Malang area operate reasonably well. Fertilizer and pesticides are readily available at highly subsidized prices. For example, a farmer in Malang can buy one kg of nitrogen in the most readily available form (urea) in exchange for only 2 kg of maize. In contrast, a farmer in Thailand can buy one kg of nitrogen in the most readily available form (21-0-0) in exchange for 9.5 kg of maize. In the past, improved maize seed was not readily available to farmers in the study area. This situation has improved considerably since 1983, when government policy was changed to encourage private firms to participate in seed production and marketing. Currently, two hybrids and one variety (Arjuna) are commercially available. Other input markets (labor, animal traction, etc.) are reasonably efficient.

Marketing: The marketing of maize for cash sale is largely in the hands of private traders, who compete to purchase maize in order to meet the rapidly expanding demand for maize by feed- mills in Surabaya. Other maize is marketed through the government marketing agency (BULOG).

Consumption patterns and taste preferences: Maize production in Malang has two major end uses: it is a major starch staple (especially for low income producers) as well as an important source of cash. About 70% of the maize that is produced is used for direct human consumption. Maize is the main non-rice starch staple in all of East Java. In the study area, many farm families consume more maize than rice. The importance of maize as a starch staple raises some concern about cooking and taste preferences, and how these might effect farmer adoption of new varieties. In East Java, farmers prefer yellow varieties. Both traditional and improved varieties, such as Arjuna and the Cargill C-l Hybrid, have a yellow grain colour. There are reports, however, that Arjuna may be somewhat more difficult to crack than other varieties for the preparation of local dishes. These dishes rely on the boiling of maize cracked to resemble rice.

2.4 Crop-livestock interactions

Crop-livestock interactions in the study area take three major forms:

1. Cattle provide draft power, for land preparation and weeding

2. Cattle manure is applied as fertilizer to selected fields
3. Maize thinnings serve as one source of livestock feed.

Manure: In any given year, about half of the farmers apply manure to their maize fields. This takes place before the first plowing for the rainy season crop. Those farmers who do not apply manure tend to be those without livestock, or those who use the manure for higher-valued crops. At least once every few years nearly all fields used for maize cropping receive manure. Manure use is of interest because of reports of P, K, S and other soil nutrient deficiencies.

Fodder: It should be noted that maize thinnings do not Beem to be an important source of cattle fodder. Other fodder Bources (including grass and weeds) are reported to be more important, even in the maize season. Furthermore, all farmers with livestock report having adequate fodder, even in the absence of maize thinnings. Many farmers who thin their maize and own livestock do not even bother to use the thinnings as fodder.

2.5 Maize production practices in the study area

Given the dominance of the maize enterprise in the study area, selected maize production practices deserve some description. Farmers in the study area follow fairly similar practices. Some of these are shown in Table 2.

Table 2. Maize production practices in the study area,

Practice	Findings	
	Quantity	Unit
Plant local variety of 80-105 days maturity	70	X
Use self supplied seed	75	%
Average seed rate	42	kg/ha
Average plant density at seeding	150,000	seeds/ha
Take out bad or weak plants	83	%
Applied manure last season	57	%
Apply nitrogen	100	%
Average nitrogen dose	162	kg/ha N
Apply phosphate (only in specific villages)	30	%
Average maize yield,local varieties	1.8	t/ha

Source: MARIF (1985).

Land preparation and planting dates: Farmers use fairly intensive land preparation practices. They plow their maize fields 2-4 times, using cattle for draft power, then harrow and level the soil. In case manure is applied, it is spread during the dry season, before plowing. The rainy season maize crop is seeded between September and November, depending on the onset of

the rains. This crop is harvested in December-February. The post-rainy season maize crop is (ideally) seeded immediately afterwards. However, excess rain at this time frequently forces some farmers to delay this planting for up to several weeks. Farmers who grow upland rice as the rainy season crop (which is usually harvested after 120 days or more) automatically are forced to plant their post-rainy season maize crop later. Thus seeding of their maize takes place several weeks after the main post-rainy season planting period.

Varieties: Relatively few farmers use recently released improved varieties (23%) although most farmers are familiar with them (72%). Few farmers purchase new seed from stores, whether certified or non-certified. Farmers indicate that yield, and tolerance to insect damage and to lodging are important considerations in selecting maize varieties. Few farmers indicate that cooking quality is a major factor in varietal selection. It should be noted that the "farmer's variety" is a complex mix of traditional varieties (e.g. Goter and Tongkol), improved varieties released more than a decade ago (e.g. Harapan), and a touch of recently released improved varieties (e.g. Arjuna).

Plant population and thinning: Farmers tend to grow maize at quite high densities. Seed rates are around 42 kg/ha, and planted densities often exceed 150,000 plants/ha. Most farmers (83%) manipulate their plant stands and remove badly developed and diseased plants. Seeding is done by hand, either in holes made by sticks or in the plow furrow. Spatial distribution varies from 70 x 25 cm to 100 x 45 cm, according to the variety and individual practices.

Weeding: Maize fields in the study area are rarely weedy, even in early stages of growth. Weeding is generally done twice. Cattle are used for weeding between rows, while weeding within the row is done by hand. The first weeding takes place about 3 weeks after seeding and is often combined with a fertilizer application and the commencement of "thinning" (removal of weak or poorly developed plants). The second weeding usually takes the form of a "hilling-up".

Fertilizer: All farmers use nitrogen fertilizer with an average N dose of 162 kg /ha. Nitrogen (in the form of urea) is usually applied twice, coinciding with the first and second weedings. These high doses are a reflection on the availability and low farm-level price of urea. Relatively few farmers use phosphate. It should be noted that most phosphate users identified in the farm survey come from the same few villages.

Pests, diseases and crop protection: Farmers are familiar with many pests and diseases but report that these seldom seriously reduce yields. Regarding crop protection, only 13 % of farmers report using pesticides, mainly Ridomil applied as a seed treatment for Peronosclerospora maydis (downy mildew). Researchers noted, however, severe and chronic infestations of

shootfly, particularly in the post rainy season.

Table 3. Fertilizer use by variety

Variable	Local varieties	Improved varieties	All varieties
Farmers using nitrogen	100 %	100 %	100 %
Average N dose in kg/ha	158	168	162
Farmers using phosphate	19 %	50 %	31 %
verage phosphate dose in kg/ha (users only)	48	69	60
Farmers using potassium	0 %	20 %	8 %
Farmers using manure	60 %	57 %	57 %
Farmers using nitrogen at seeding	n.a.	n.a	15 %
Farmers using nitrogen at 3 weeks after seeding as first application	n.a.	n.a.	85 %

Source: MARIF (1985). n.a = not available.

Post harvest operations and disposal of produce: Maize is harvested by farmers 10 to 20 days after physiological maturity. Harvesting is done by hand. Ears are carried to the farm house and sundried for several days. After drying the moisture content of the grain is often above 18X. Seed for the next planting is mostly selected from the last harvest. Selected ears or seed for planting are stored above the cooking place to prevent losses caused by storage insects and rodents. Only a few farmers buy new seed after the original purchase of a new variety. Most farmers in the study area use their maize crop for home consumption, with occasional sales of surplus quantities.

Differences between rainy- and post-rainy season cropping: So far the discussion dealt with the rainy season and the post- rainy season maize crops as being managed in a similar way. However, differences between the two crops exist and are indicated below:

- Land preparation is usually more intensive for the rainy season crop
- Manure is mainly applied before seeding of the rainy season crop
- Throughout the study area, seeding of the rainy season crop takes place more or less at the same time, that is immediately after the onset of the first rains, and cover only a few weeks. However, seeding of the post-rainy season crop shows a large variation in planting time, that may cover a period of over one and a half months.
- Shootfly problems appear to be more severe in the post-rainy season.

3.0 DIAGNOSIS: PROBLEMS AND THEIR CAUSES

This section emphasizes problems associated with maize production, because maize is by far the most important crop enterprise in the study area. Maize is a major starch staple, and a major source of cash income. The only other crop grown by study area farmers to any significant extent is upland rice, which is not included in MARIF's research mandate.

The MARIF team members have continuously advanced in understanding the problems affecting the productivity of the maize crop. Initially, the team noted that:

> "Despite intensive management, including proper tillage practices, row planting, adequate weeding practices, high nitrogen and manure applications, maize crops in the domain, regardless of variety, show symptoms of spindly stalks, and discoloured leaves. Yields are low, with an average of 1.8 t/ha grain and only few farmers obtain yields above 2 t/ha. Yet on-station research indicates that 5 t/ha can easily be obtained from Arjuna (MARIF, 1984).

At first, attention was focused on three factors: variety, plant population and fertilizer management. However, it became evident during the fieldwork that other problems required attention, including early season insect damage and seed quality. As research continued, the team gained a better appreciation for how these problems interact, and the particular causes of each.

The problems affecting maize production, as currently understood, are as follows:

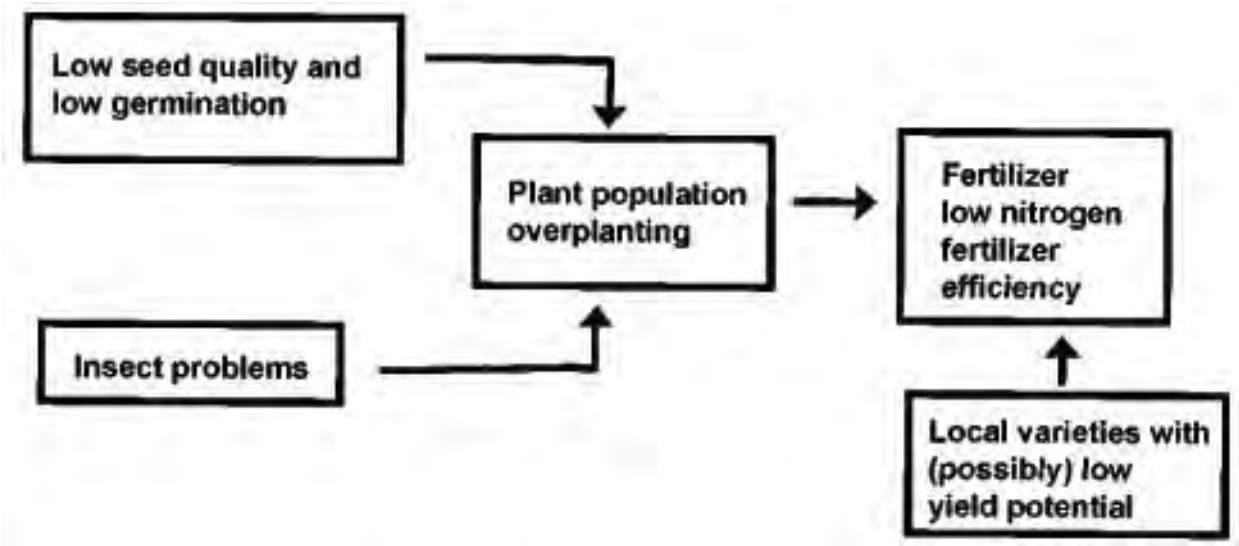
1. Maize yields are low because most farmers use low quality seed, of varieties with (possibly) low yield potential.
2. Maize yields are low because of damage during the early growth stage caused by Atherigona spp. (shootfly) and Phyllophaga helleri (white grub), resulting in growth retardation and reduction of plant stands.
3. Maize yields are low because farmers use excessively high seed rates, resulting in interplant competition during early growth stages.
4. Maize yields are low (and production costs high) due to low fertilizer efficiency.

These problems and some of their interactions are presented in Figure 2. Note that low seed quality and shootfly damages are causes of overplanting and that overplanting contributes to a lower fertilizer efficiency.

Each problem and its respective causes are discussed in more detail in the following sections.

Figure 2: Components of main problems

Factors effecting yields



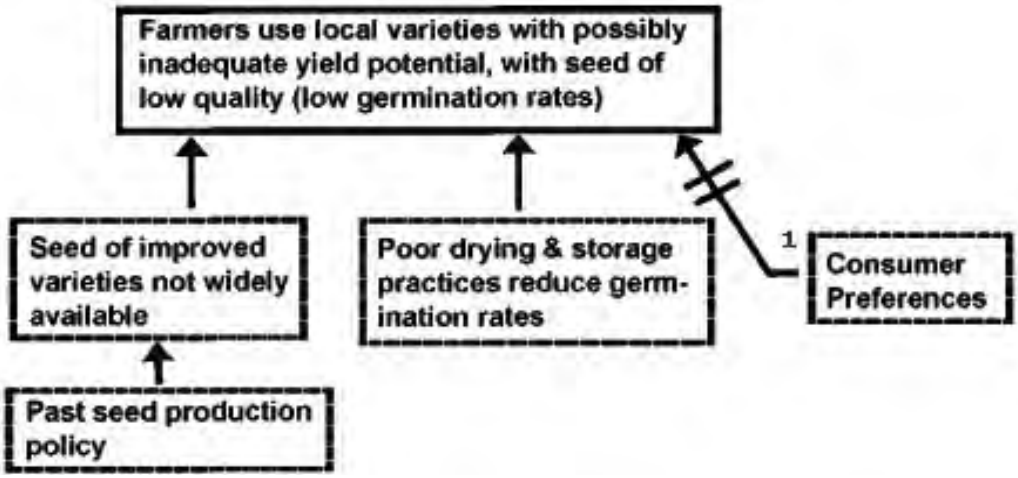
3.1) Variety and seed quality

One factor explaining Ion farm-level yields is seed, covering the genetic potential of the farmers' variety as well as the quality of the seed itself at planting time. Regarding variety and yield potential, many farmers use improved varieties released many years ago, such as Perta (1956), Harapan (1964) and Arjuna (1980). These farmers save from each harvest some seed for the next planting. Due to cross pollination with traditional varieties and land races, genetic erosion may occur and varieties gradually decrease in varietal purity and yield potential. It should be noted, however, that in some of the on-farm trials, these varieties performed very well and had yields not significantly lower than recently introduced improved varieties, when grown under conditions of improved management.

Findings from the maize production survey held in 1984, indicated that only 23% of the farmers plant Arjuna, the most recently released variety, largely due to problems with seed availability. Arjuna matures in 95-100 days, other varieties range in maturity from 85 to 115 days.

Regarding seed quality, researchers suspect that low germination rates and poor seedling vigor enter into farmers' decisions to overplant. This suspicion has received support from the formal production survey (42% of farmers mentioned low seed quality as a reason for over-planting) as well as seed handling and storage surveys recently implemented by MARIF. Seed-related problems and causes are shown in

Figure 3: Variety and Seed Quaiity



[1] Not supported by research results

3.2 Insect damage

Maize in the study area is often damaged in the early stages of growth by shootfly and whitegrubs. Major causes of this problem include a high natural incidence of these insects, and late planting of maize. In turn, late maize planting is caused {for the rainy season) by uneven distribution of early rains and competition for labor with sawah crops. In the post-rainy season, late maize plantings may be caused by: (1) a late planting of the rainy season maize crop; (2) planting maize after a rainy season crop of upland rice; (3) excessive rainfall lengthening the turnaround time between the two maize crops. The severity of insect problems varies greatly from one year to another. The rainy season maize crop typically suffers somewhat less from insect damage than the post-rainy season crop. Interactions between the insect problem and its causes are shown in Figure 4.

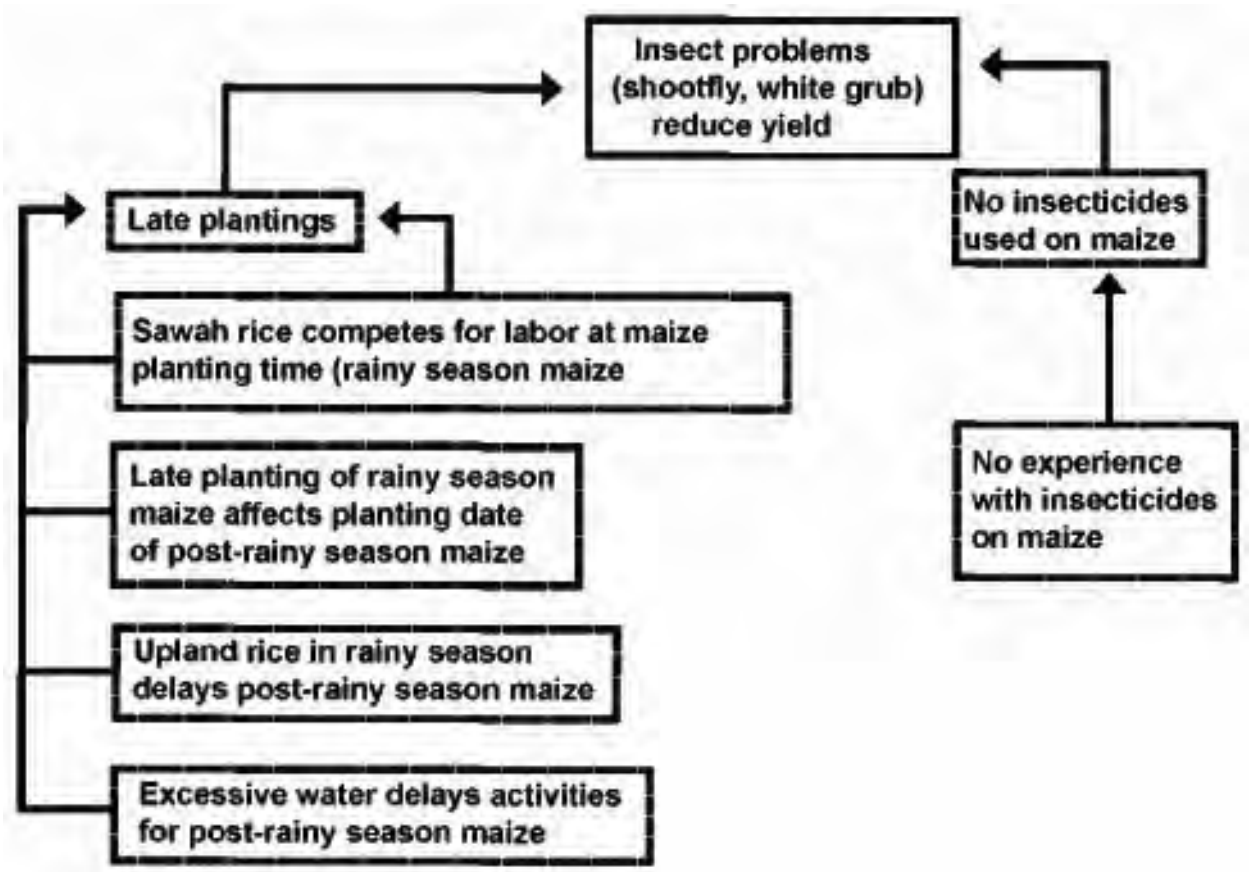
3.3 Plant population management

The farmers' practice of overplanting (at times in excess of 150,000 plants/ha) then "thinning" (systematically removing damaged, diseased or poorly developed plants) leads to severe interplant competition in the early growth stages, as well as a low harvested density (less than 50,000 plants/ha). There seems to be a number of possible reasons for this practice:

1) To compensate for expected damage and loss of plant stand due to shootfly and whitegrub attack

2) To compensate for expected low seed germination rates and uneven plant vigor, in turn caused by farm-level seed storage problems

Figure 4: Insect problems



3) To provide fodder for livestock. (It was originally-thought that farmers might overplant and thin their maize in order to obtain fodder for their cattle. However, as was seen in an earlier section (2.4) this does not seem to be the case.)

Interactions between the plant population problem and its causes are shown in Figure 5.

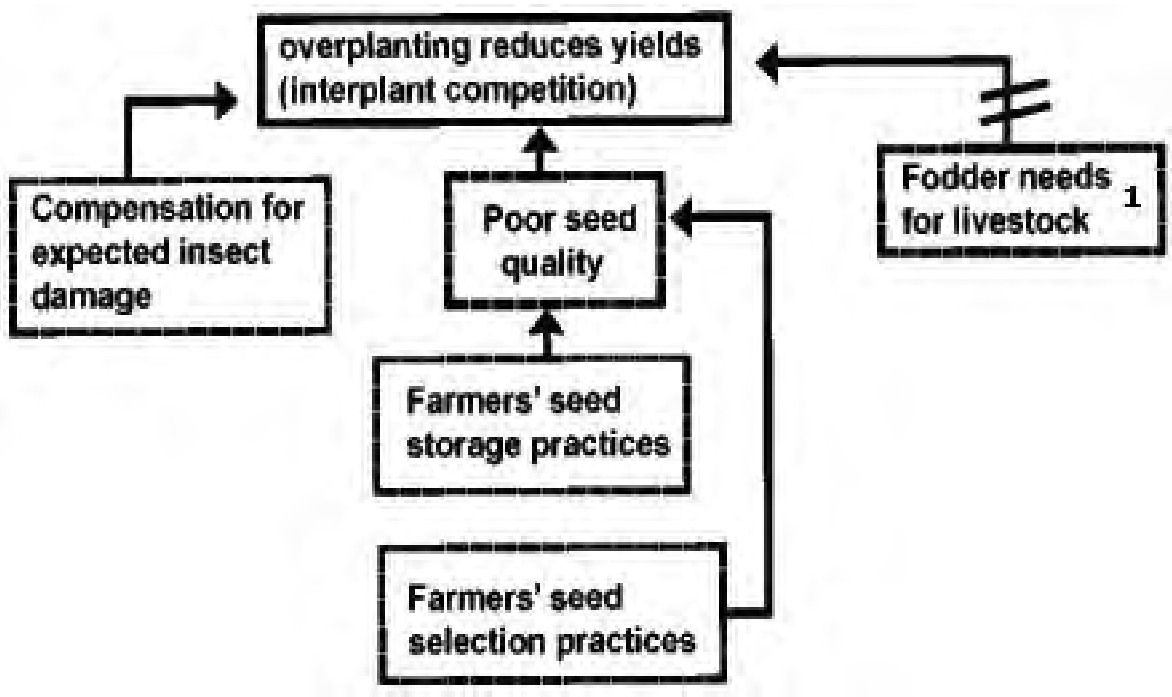
In view of these causes, possible solutions to the plant population problem were seen to involve insect control and seed storage practices as well as seed rates.

3.4 Fertilizer management

Farmers apply on average 162 kg/ha N to their maize fields, but do not obtain high yields. This problem could be explained as follows:

Timing, amount and method of nitrogen application: Virtually no farmers apply more than a negligible dose of N (3-4 kg/ha) at planting. Most farmers give the first N application 2

Figure 5: Plant population



[1] Not supported by research results

to 4 weeks after planting. Farmers, aware of the damage caused by shootfly and white grub and of plant losses due to poor, seed quality, prefer to postpone fertilizer application until à good plant stand is obtained. Some farmers also have learned that urea mixed with seed will burn the seed. They have little experience with other application methods, e.g. urea placed in an adjacent hole, 10 cm away from the seed.

Other nutrients and manure: Most farmers use only nitrogen fertilizers and do not use phosphate or potassium on their maize crop, though soil analysis show that most of the young volcanic soils are deficient in both elements. One source of P and K is manure, which (during 1984) was applied by about half of the farmers. It is estimated that most farmers will have applied manure to their maize crop at least once every five years.

Overplanting: High plant stands during the early growth season are due to high seed rates. Severe competition between many plants reduces the grain production per kilogram of N applied.

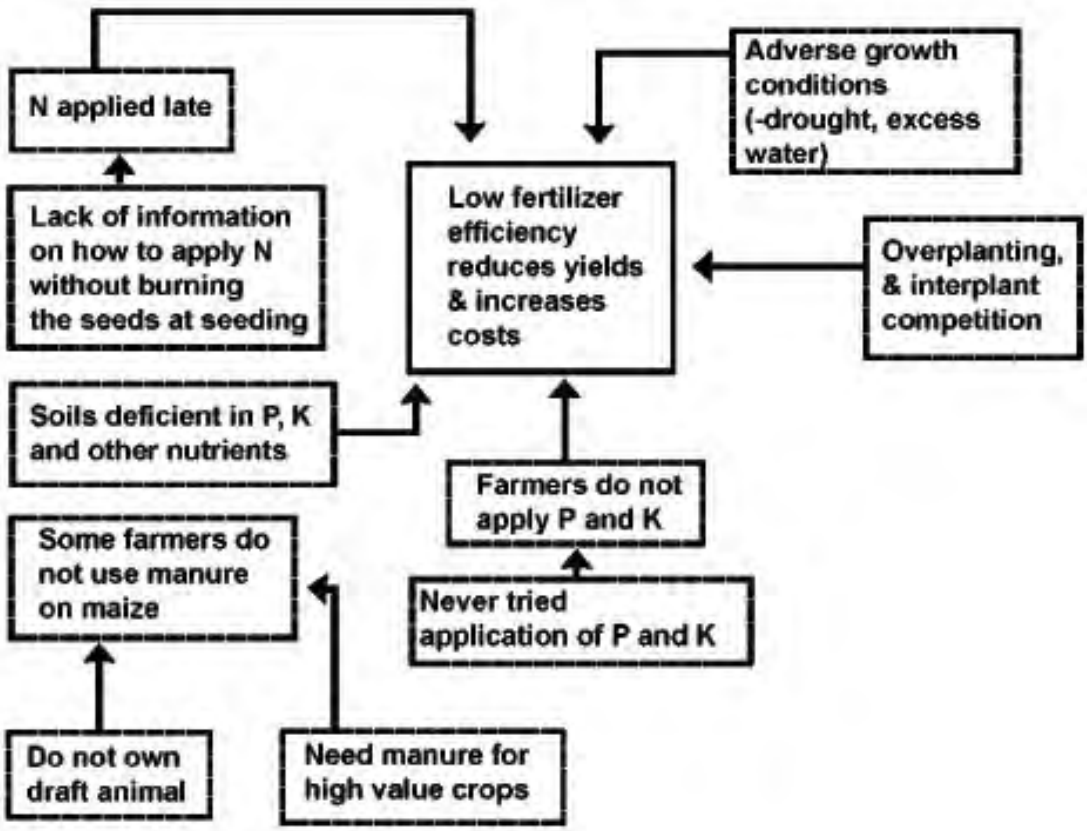
The problem of fertilizer management and related causes are shown in Figure 6.

Given the array of causes noted above, possible solutions to the fertilizer management problem include:

- Prior solution of the problems of insect attack and overplanting

- Earlier N application

Figure 6: Fertilizer Management



- Lower N dose

- Application of P and possibly other nutrients.

4.0 EVIDENCE FROM ON-FARM EXPERIMENTS

The problems discussed in the previous chapter were examined in the five cycles of on-farm experimentation conducted so far. Some experiments served to further define problems, while other experiments looked at possible solutions. As will be seen, the results of the trials are fairly consistent and tend to support the hypotheses given in the diagnosis. It appears that farmers' maize yields can be doubled through simple improvements in management practices at a moderate increase in cost. Altogether, the team conducted seventy-one on-farm trials in seven villages, with twenty eight different farmers participating. Some farmers cooperated with only one trial in one season, other farmers participated during all cycles, but not necessarily with the same field.

The cyles of field trials conducted or planned by the MARIF maize OFR team in the young volcanic study area are referred to as:

Cycle No. 1	1984 post-rainy season
Cycle No. 2	1984/1985 rainy season
Cycle No. 3	1985 post-rainy season
Cycle No. 4	1985/1986 rainy season
Cycle No. 5	1986 post-rainy season
Cycle No. 6	1986/1987 rainy season

An overview of research activities is presented in Table 4. In the following sections a summary is given of the on-farm trials by subject. Details on treatments, lay-out, management and findings of these trials may be found in MARIF OFR Working Papers 3, 7, 9, 15 & 19, which cover the first to fifth cycle of on-farm trials.

Table 4: Activities of the MARIF OFR team in the young volcanic study area during the period 1984-1986

Activities	Cycle				
	1	2	3	4	5
On-Farm trials	*	-	-	-	-
Exploratory	*	*	*	*	*
Variety	-	*	-	*	*
Fertilizer	-	-	-	*	*
Crop protection	-	-	*	*	*
Seed	-	-	*	*	*
Farmers observation	-	-	*	*	*
Verification	-	-	*	*	*
Survey					
Exploratory	*	-	-	-	-
Maize production	-	*	-	-	-
Seed storage	-	-	*	-	-
Shootfly	-	-	-	*	*
Other activities					
Pot experiments	-	*	-	*	*
Soil analysis	-	*	-	-	*
Field days	*	-	*	-	*

4.1) Variety

Variety trials were conducted in all five cycles. In each trial cycle from one to three locations per cooperating village were used, and thus over five cycles a total of 19 trials were conducted. The objective of tne variety trial was to study the performance of improved varieties under farmer conditions and to compare these improved varieties with varieties used by farmers,

using the improved management practices. Lay-out, management and observations for each of these trials were roughly similar over all five crop cycles and are described in detail in the working papers. Arjuna from the seed stock of the MARIF was used as reference in all cycles. A summary of these data covering five cycles of trials over 19 locations is presented in Table 5.

Experimental data from individual trials indicate that improved varieties rarely yield significantly more than the farmers' variety, under improved management conditions. This is consistent with the pooled data shown in Table 5. One explanation for this lack of response may be that there are two kinds of farmers' variety - the "true" local varieties (e.g. Tongkol, Goter) and improved varieties released over the last 30 years (e.g. Metro 1956, Perta 1956, Harapan 1964, etc.). In the variety trials, farmers were asked to supply the seed for the "farmers' variety". Most farmers used varieties from the second category (improved varieties released over the last 30 years). If this is representative of most study area farmers (and this is being double-checked), then "variety" may be of much less importance than management issues.

Table 5: Results of varietal testing conducted in the young volcanic study area during the period 1984-1986. Five cycles with 19 locations. Yields with a moisture content of 15%.[1]

Variety	Grain yield (t/ha)	Number Locations	
		Locations	Seasons
Hybrid C-1	4.3	13	3
Hybrid CP-1	4.4	5	2
Arjuna BISI	4.2	5	2
Arjuna MARIF	4.3	19	5
Muneng Synthetic 3	4.2	19	5
Malang Composite 9	3.9	15	4
Suwan 1	4.4	11	2
Arjuna x Center	4.5	2	1
Harapan MARIF	3.2	7	1
Harapan farmer	4.2	14	3
Best farmers’ variety	4.6	6	2
Total	4.2	-	-

[1] We recognize the limitations of this kind of pooling in testing hypotheses. These data are presented as illustration, not as hypothesis testing.

It should be noted, however, that non-yield factors may also be of some importance. Specifically, Arjuna enjoys a higher

degree of resistances to downy mildew and to lodging when compared to farmers' varieties. Regarding yield stability, four entries (Arjuna, Hybrid C-l, Muneng Synthetic 3, and farmers' Harapan) showed good stability over locations and over cycles.

4.2) Plant protection

Early insect damage might conceivably be reduced by finding ways to eliminate late planting. However, a simpler and more effective way would be to use appropriate insecticides. The major insect control treatment tested by researchers was the application of carbofuran 3% granules in the hole at planting time, at the rate of 0.3 kg/ha a.i. Evidence on shootfly incidence and on yield losses due to early season insect attack were generated by a number of research activities: These are summarized in Table 6.

The economics of the carbofuran treatment appear quite favorable. Costs that vary (insecticide and application costs) are only Rp 3850 per ha (US$1 = Rpll20). Using a minimum rate of return of 50% and a maize field prices of Rp 110 per kg., the breakeven yield increase is estimated to be only 52 kg/ha! Kote that carbofuran is heavily subsidized, due to its importance in rice cultivation. It may be noted in passing that there is considerable evidence of early farmer adoption of plant protection measures (and spontaneous reductions in seed rate and plant population) in villages where OFR activities were conducted. This will be quantified in a forthcoming survey.

4.3) Plant population

Farmers are observed to overplant (up to 150,000 plants per ha) and then thin (take out damaged or poorly developed plants), largely due to concerns about shootfly (and other early season insect) attack, and possible poor seed quality. Recall that farmers adopting carbofuran to control shootfly have been observed to spontaneously reduce seed rates). A number of OFR activities have generated data on the issue of plant population. These are summarized in Table 7.

The data seem to indicate that two facters are at work in the farmers' practices: excessively high density at planting time (leading to interplant competition) and low densities at harvest. Farmers appear to harvest (for one reason or another) only about 1/3 of what they plant! It seems that farmers can achieve a higher yield and a higher harvested density - by using a lower seed rate in conjunction with shootfly control through carbofuran, and without thinning at all.

4.4) Fertilizer Management

It was observed during the exploratory survey and production survey held in 1984, that farmers' maize yields were generally less than 2 t/ha, despite high inputs of nitrogen chemical fertilizer and use of manure. Under farmers' practice, the

Table 6: Summary of findings on plant protection, young volcanic soils study area, cycles 1 - 5, 1984-86

Activity	Cycle[1]	Result
Exploratory trial	1	Trials were heavily damaged by shootfly. No control measures were used. Plantings were 2-4 weeks later than the main planting time.
Verification trial	3	Use of the carbofuran treatment, superimposed on the unmodified farmer practice, resulted in a 1000 kg/ha yield response (from 2.2 t/ha to 3.2 t/ha).
Shootfly trial	4	The carbofuran treatment increased yields by 800-900 kg/ha.
Verification trial	4	The carbofuran treatment, superimposed on the unmodified farmer practice, increased yields 700 kg/ha.
Shootfly survey	4,5	Maize planted early in the season showed shootfly incidence of 3-23%. Maize planted 3-4 weeks later showed shootfly incidence of 70-80%. Rainy season infestation levels were lower than for post-rainy season. Observations were taken on three-week-old plants.
Shootfly trial	5	Carbofuran treatment 900 kg/ha yield response.
Verification	5	Yield response 440 kg/ha when carbofuran superimposed on farmer practice.

[1] Trials were planted early in cycles 4 and 5, leading to level of shootfly infestation lower than observed for neighboring farmers.

Table 7: Summary of findings on plant population, young volcanic soils study area, cycles 1-5, 1984-86

Activity	Cycle	Result
Exploratory trial	1	Reduced plant stand from 150,000 to 90,000 plants per ha at planting increased yields by 600 kg/ha (NEV = improved variety, good quality seed)
Verification trial	3	Increased plant stand at harvest from 55,000 to 70,000 plants/ha increased yields by 400 kg/ha, at no increase in cost

nitrogen was applied in equal amounts at about 3 and 6 weeks after seeding. Observations in the field showed discoloured leaves during early growth, frequent stem lodging and spindly plants. All these factors pointed to an unbalanced nutrient system.

OFR activities on fertilizer management examined the following alternatives to the farmers' practice:

Factor	Farmer Practice	Alternative
N dose	162 kg/ha	92-138 kg/ha
N timing	1/2 at 20 days 1/2 at 40 days	1/3 at planting 2/3 at 20-30 days
P dose	(-0-)	60-90 kg/ha P

A large number of OFR activities were devoted to studying fertilizer issues. During the second cycle of experimentation, a HPK factorial trial was conducted at four locations. In addition observations were made on the application time of nitrogen. Furthermore, soil samples were taken from 5 locations in the study area, to be used for chemical analysis and for a fertilizer experiment in the greenhouse. During the fourth and fifth cycle, the response of maize to combinations of N and P was studied over several locations and over seasons, while the response to potassium applied in combination with N and P was separately studied in the field. To support the fertilizer studies in the

field, research extended to nutrient availability studies in young volcanic soils. The method of the "Double Pot" technique was used and included 11 nutrients and soil from 5 locations. Responses of maize grown at similar NP levels in other trials, such as the varietal trial, were compared to maize grown in fertilizer trials. Detailed results of all research activities are given in working papers 3, 7, 9, 15 and 19. A summary of OFR results is given in Table 8.

The evidence from these trials seems to indicate that farmers can profitably use less N, but should invest in some P, and that N timing is also quite important. The evidence on K, S, etc. is not yet clear. It should be noted that the fertilizer response data are uniformly taken from trials using shootfly control and improved plant population. This is because farmer adoption of fertilizer management innovations is likely to come after adoption of plant protection and improved plant population technology.

The economics of improved fertilizer management are reasonably attractive. Costs that vary are as follows:

Category	Farmer's Practice	Alternative
	(--------Rp/ha---------)	
N dose	162 kg/ha	92 kg/ha
N fertilizer	44,000	25,000
N/P application	(same)	(same)
P fertilizer (92 kg/ha)	0	25,000
Total	44,000	50,000

Using a 50% rate of return, then, increased costs can be recovered with an insignificant yield increase (55 kg/ha). Agronomic data indicate that the expected response is usually over 1 t/ha!

4.5) Verifications

Verification trials (large plot, unreplicated trials conducted in cooperation with extension workers) were conducted in cycles 3 and 5. The objective of these trials was to double-check the consistency of yield responses and net benefits to the alternative practices described in previous sections. Treatments, lay-out, management and observations for each cycle of these trials are described in detail in working papers 9, 15 and 19.

Table 8: Summary of findings on fertilizer management, young volcanic soils study area, cycles 1-5, 1984-86

Activity	Cycle	Results
Exploratory trial	1	Reduction in N dose from FP to 138 kg/ha N resulted in no yield reduction. Application of P increased yields by over 1 t/ha.
Fertilizer trials	2	Yield response of 700 kg/ha when N increased from 46 to 138 kg/ha. Insignificant yield responses to medium P dose (46 kg/ha P - drought this cycle). No effect of K on yields, in the presence of P. Change in N timing gave yield response of 400 kg/ha to earlier application.
Fertilizer trials	4	Reduction in N from 138 to 92 kg/ha led to no yield decline. Application of 46 kg/ha P led to 400 kg/ha yield response. No strong NP interaction.
Verifications	4	Improved fertilizer management (lower N dose, earlier N, P application) led to 1.7 t/ha yield increase.
Fertilizer trials	5	Reduction in N from 138 to 92 kg/ha led to no yield decline. Application of 92 kg/ha P led to 880 kg/ha yield response.
Verifications	5	Improved fertilizer management increased yields by 34%.

Verification trial treatments were changed between cycles 3 and 5, as researchers improved their understanding of farmers' problems and likely solutions. Treatments that were common to both cycles of trials, and their corresponding yields, are summarized in Table 9.

Table 9: Results verification trial

Treatment[1]					Dry grain yield (t/ha)	
No.	V	P	FR	C	Cycle 3 (N = 11)	Cycle 5 (N = 3)
1.	F	F	F	P	2.2	2.4
2.	I	I	F	I	3.2	3.9
3.	I	I	I	I	4.4	4.4

[1] V = variety; P = plant population; F = fertilizer; C = crop protection

F = farmer's practice; I = "improved" alternative

It should be noted that most farmer cooperators seem to be somewhat progressive, with yield levels above average (1.8 t/ha being the average yield found during the production survey). An effort is being made in cycle 6 to select larger numbers of representative farmer cooperators from a larger number of villages.

The economic analysis of these verifications (not shown here due to space limits) indicates that the marginal rates of return earned from increased increments of investment are as shown in Table 10.

Table 10: Marginal Rates of Return Earned by Increased Investment, Verification Trials, Cycles 3 and 5, at 1986 Prices

Treatment Change[1]	MRR Cycle 3	MRR Cycle 5
	----- (%) -----	
$T_1 \rightarrow T_2$	450	725
$T_2 \rightarrow T_3$	542	Í67

[1] See Table 9 for treatment descriptions.

5.0 THE EVOLUTION OF RESEARCH THEMES AND PRIORITIES

Research priorities have not remained static during the 2 1/2 years of research in the study area. Some themes thought to be of importance have been dropped; other themes that were initially under-rated have come to take their place. This is a natural consequence of a continuously improved understanding of farmers' circumstances and problems. Salient features of this evolutionary process include:

Variety

In early research cycles, variety was thought to be a key factor (even heavily-fertilized maize was observed to be spindly). Research has shown, however, that under improved management conditions on representative farmers' fields, many farmers' varieties perform about as well as Arjuna and the commercial hybrids. Variety has declined in priority.

Shootfly and Seed Quality

The importance of the shootfly and seed quality problems, and their effects on plant population and fertilizer efficiency, were initially under-rated. The shootfly issue was recognized as early as cycle 2, has been fairly well studied, and is now declining in priority. Seed quality issues were only recognized in cycle 3 and are still being pursued.

Fertilizer: N, P, and N Timing

These factors were recognized early, have been thoroughly studied, and research activities as such are now about finished, although verification and farmer assessment continue.

Fertilizer: Other Nutrients

Soil test data and greenhouse experiments have indicated deficiencies of K, S, Mg and Zn. However, the application of these elements in the field has not led to unambiguous increases in yield. Study of these elements has declined in priority.

Extrapolation, Farmer Assessment, New Study Areas

The activities with the highest priority at the present time include expanded verification (in cooperation with extension workers); assessment by farmers of the alternative management practices; extrapolation of the target study area to districts outside of Malang; and initiation of OFR in a new study area where three palawija crops (cassava, maize, soybean) are included in the research program.

Annex 1.

MARIF MAIZE ON-FARM RESEARCH PROGRAM
WORKING PAPERS

Number of Paper	Title	Status: Completed	Status: Planned for
1.	Joint Proposal for the MARIF On-Farm Research Programme for Maize	Jan.1984	
2.	A Maize On-Farm Research Programme - Development of a methodology	Apr.1984	
3.	Trials results of the MARIF Maize On-Farm Research Pro-Gramme -1984 First Dry Season	Sept.1984	
4.	Report on study tour to Thailand - August 1984	Sept.1984	
5.	Synopsis: The MARIF On-Farm Research Programme for Maize based farming systems	Oct.1984 (revised Jan.1985)	
6.	An Introduction to the MARIF On-Farm Research Programme for Maize based Farming Systems	Mar.1985	
7.	Report on the Trial Results - Series no. 2 Rainy season 1984/85	May 1985	
8.	Report on the Maize Survey - December 1984	May 1985	
9.	Report on the Trial Results - Series no. 3 First Dry Season 1985	June 1986	
10.	Note: The Shootfly Issue	Aug. 1985	
11.	Notes on: On-farm maize seed storage	June 1986	
12.	Notes on: Inputs in maize on-farm trials	June 1986	
13.	Costs and Benefits of On-Farm Research	Jan. 1986	
14.	Report on a study tour to Thailand - August 5-14, 1985	Sept.1985	
15.	Report on the Trial Results Cycle no. 4 -Rainy season 1985/86	June 1986	
16.	The Downy Mildew Issue	May 1986	
17.	The Second Shootfly Report	Oct.1986	
18.	Report on the exploratory survey in the limestone area with maize/cassava based farming systems - January 1986.	Nov. 1986	
19.	Report on the Trial Results Cycle no. 5, Post-rainy season 1986	Oct. 1986	

Annex 2.

Arrangements between farmer co-operators and the MARIF research team for on-farm trials.

1. The team based on findings from previous trials, surveys and other observations determines the need for a specific type of trial, to test hypotheses formulated.

2. Within the study area, the required number of villages are selected depending on subject and type of trial (1. exploratory, 2. level or 3. verification type of trial).

3. In the village(s) selected, the team contacts its contact person.

4. The contact person asks 2 to 6 farmers to cooperate, who grow maize under rainfed conditions.

5. With each co-operating farmer the MARIF team makes an oral arrangement, to work together, with "closed pockets".
   - The cooperating farmer brings in his land and labour and inputs (required for these parts of the field not needed for the trial or to represent the farmer practice).
   - The MARIF team brings in seed, fertilizers and chemicals (as needed) for the trial designed.
   - The farmer carries out all the management steps as usual, land preparation, weeding, harvesting.
   - The MARIF team together with the farmer and his helpers plants the trial.
   - The MARIF furthermore carries out those management activities as described in the trial as fertilization, crop protection etc. The farmer carries out all other farm activities.
   - The MARIF staff takes observations, including weighing of the harvest of selected parts of the trial field.
   - After all observations are completed the entire harvest is given to the farmer. So far in all cases farmers received more yield as usually obtained from the same field.
   - The farmer will receive compensation for his losses in case of a crop failure. (In five cycles with over 70 trials, only one time a crop failure occurred in a small part of a specific crop protection trial for which the farmer was reimbursed).

References

Byerlee, Collinson, *et al*, 1980 (Manual II).

MARIF, 1984. "Report on the Maize Survey - December 1984". MARIF OFR Working Paper No. 8.

The FSR & D - Extension Linkage: Experience from Mali

Kees Verbeek, Bakary Sanogo and Paul Kleene, Farming Systems Research Division*

1. Introduction

FSR & D methodology, as it was developed in the mid- seventies, can be seen as a direct result of the growing awareness of the relatively modest impact of commodity based and discipline-oriented research applied to a highly complex reality of small holder agriculture in developing nations (Zandstra 1983). Source methodology was developed almost simultaneously by different individuals, working at different institutes located in different eco-climatic zones, it took time to reach a consensus on what FSR & D really stands for. However, the growing body of literature on the subject published in the early eighties suggests that FSR & D should not be seen as a ready-from-the-shelves blueprint for the development of productivity improving technologies but much more as a type of research that meets certain well-defined characteristics and a certain sequentional follow-up of clearly stated research phases (Shaner et al. 1982, Gilbert et al. 1980, Simmonds 1984). This then leaves room for considerable flexibility in research design, organization and timing, depending mostly on the objectives aimed at, and the geographical location and institutional setting of the research.

In this paper, the authors attempt to retrace the way strategy and methodology were adapted to fit a particular institutional setting in order to obtain research results scientifically viable as well as directly applicable. In the last chapter, a pre-extension program is discussed which served as a final stage between FSR and Development.

2. General Setting and Farming Systems

FSR & D in Mali was initiated in 1979 and has been focused until recently on the country's major production zone for rainfed agriculture, "Mali-Sud".

Mali-Sud covers an area of 92 000 km2 and provides a living for 2.2 million rural inhabitants living in 3,250 villages. The area is situated in the Sudanese climatic zone (rainfall 700-1,200 mm/year). Principal crops are sorghum, millet, maize and cotton. Of minor importance are rice (in the low lands), and groundnuts (mostly in the dryer zones).

Animal traction plays a dominant role in the farming systems and is seen as the major technical innovation by the development agency in the region as well as farmers (1).

(1) The term "development agency" is used often synonymously with the term "extension agency". However, the authors prefer the former expression since CMDT encompasses a comprehensive range of activities

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Cotton and to a less extent maize, are commercialized and together cover about 25-40% of the cultivated area on a typical farm (1). These are grown in a relatively intensive way, and benefit from mechanized land preparation, improved seeds, timely planting, optimal densities, mechanical weeding and inorganic fertilizers. Yields are consequently high. Sorghum and millet (typically covering about 50-60% of the cultivated area) are cultivated in a relatively extensive way, benefit from some mechanization, but generally fertilizers are not applied on these crops. Production is optimized more per unit of labor, than per unit of land. The most common rotation pattern is cotton, maize (intercropped or not with millet), sorghum, but other crop sequences exist as well.

The area is relatively well covered by a rural extension, development and marketing organization called as CMDT (Compagnie Malienne de Développement des Textiles). This agency, due to its efficient management of its vertically integrated cotton operations, plays a preponderant role in rural development at the village, regional and national level.

3. Institutional Setting

a. Research

Farming Systems Research is carried out by the Institute for Rural Economy (Institut d'Economie Rurale - IER), under the Ministry of Agriculture responsible for agricultural research in Mali. A separate farming systems division (Division de la Recherche sur les Systèmes de Production Rurale - DRSPR) was created in 1979. Most other agricultural research (commodity research, fruits, vegetables) is the responsibility of agronomic research division of IER (Division de la Recherche Agronomique). Situated in this context, Mali has opted for what now is known as "downstream FSR approach" (Norman, 1983). Since commodity and discipline oriented research fall under the same institute as Farming Systems Research, linkages were assured from the start and developed in a positive way as the FSR division was getting established in the Institute. These linkages are assured by:

- annual presentations of results of both types of research in a formal commission (2) in which all researchers as well as representatives from development agencies participate;

(1) Cultivated areas typically are between 4 and 12 ha per farm

(2) Technical commissions of IER chaired by the Director General of IER which meet annually

- a coordination committee consisting of staff members of both research divisions, meeting regularly to discuss fields of collaboration and to exchange information on research and technology;

- the policy of the farming systems research division to invite researchers from other divisions to carry out special studies to fill in the "blind spots" in research;

- the availability of a budget to facilitate the above, especially for research units which do not benefit from external financing;

- the availability of facilities for commodity and discipline oriented research on the research station run by the farming systems division. This facility is much appreciated and many researchers use it to conduct their multi-locational stability tests.

b. Development

At the other end of the continuum the FSR division is forward linked to the extension service. The area has the advantage of being served by only one development agency: the CMDT, which, besides its principal role in cotton production and marketing, has extended its activities to other crops (maize, rice, groundnuts) and animal husbandry. It provides short-term credit necessary for the purchase of inputs (mainly seeds and fertilizer) for these activities. In addition to this, it renders a wide range of other services to farmers e.g. adult education, promotion of pre-cooperative societies, training of blacksmiths and support for women's activities.

The organization has a history of efficient management based on a well organized but heavy monitoring system and is widely regarded as a good example of integrated rural development.

The following organizational characteristics of the development agency seem particularly relevant to the FSR division:

- at the top and middle level, the organization is staffed with often highly experienced agents with a good knowledge of field conditions;

- the organization as a whole has a rather inward-looking attitude. There is a strong "esprit de corps" and a noticeable reservation vis-a-vis other (government) organizations;

- although at the higher level of the organization there exists certainly much awareness of the importance of non-cotton activities, this is much less so at the middle and lower levels where the extension activities and activities related to the administration of cotton production and marketing remain the major preoccupation.

From the simple fact that FSR was initiated about 25 years after the development agency started its activities in the area (1), and given the organizational characteristics of the development agency as mentioned above, it might be clear that it took time (2-3 years) for the research teams to come to terms with the development extension agency. Initially, the team often found itself in a position of a kind of salesman of research results knocking at every possible door to get its messages sold.

At the outset formal relations with the development organization were limited to the mere presence of their representative at the annual presentation of research results of the FSR division.

4. Implications for Research Objectives and Policy

Given the institutional setting above described, it was clear from the start that the FSR team had to adopt an active attitude in order to close the gap between research and extension. Although much of this process was in fact a trial and error experience, the following policy lines have been particularly helpful to facilitate overcoming the initial comparative disadvantage.

- Malian authorities have opted right from the beginning for a long-term research commitment as opposed to a project like set-up with a restricted time table. This enabled FSR to get more in-depth knowledge of farmers practices and motivations, thereby slowly gaining acceptance as a knowledgeable group by the development agency (2). On hind sight, one can say that this process could have been speeded up had initial financial resources been less restrictive and balance between biological, physical and socio-economic research topics been emphasized (in the preparatory as well as the first years of FSR existence the latter dominated the former. However, we believe that

(1) CMDT was preceded by CFDT the French cotton production and marketing organization active in many of the francophone states in West Africa

(2) FSR was preceded by a socio-economic action research program based on participative village surveys.

this period had an acceptable pay off (1) in terms of gaining a thorough knowledge of the farming systems in the area, often based on a day to day observation of the farming systems and practices. In this period a long term view on agriculture in the area was developed which later on guided important research policy choices (see Kleene and Vierstra 1985 for details).

- To involve the development agency in every stage of research implementation and to put emphasis on training of their staff and field agents by means of seminars, training sessions, field days and in some cases on the job training.

- To evaluate every technology proposed not only from a technical and economic angle but also from the perspective of institutional feasibility. This includes such items as farm classifications based on parameters which are hard to measure by relatively untrained field agents and a credit scheme manageable by the same agents. It is evident that the researcher sometimes had to compromise on a more simplified final product than he initially aimed for.

- The adoption of a balanced research program leading to tangible results in a relatively short period (fertilizer recommendations, better performing agricultural equipment) while others aimed at more long-term objectives like maintaining the balance between the demanding farming systems and the available resources of the eco-system.

- A particular emphasis on extension methodology to accompany well defined technology packages responding to farmers' needs.

It was these policy choices varying in importance according to the stage of research, which contributed significantly to the creation of healthy working relationships with the development agency, enabling the FSR team to develop common activities in various fields. However, a few other contributing factors deserve to be mentioned as well in understanding this process:

- The long-term objective of the development agency to restructure their extension organization in a way to leave more responsibilities to young farmers who successfully completed the adult education program, coincided with the availability of such a method and approach developed by the

(1) In fact, the policy that every new researcher should, at least the first year, spend the maximum of his time in the field having responsibility for implementation of on-farm tests and special studies has contributed to this pay-off.

FSR team. The methodology was labelled "Conseil de Gestion" and was adopted on an experimental basis (see Kleene 1984). This gave the research team apart from gaining experience in extension methodology a platform to test technologies on a pre-extension phase.

- Pressure from the donor agency for producing immediate applicable results on a large scale. This has led to formalization of relations through a memorandum of agreement between the two partners, giving the FSR division direct access to top level officers at the development agency (a fact which cannot easily be under-estimated in a strong hierarchical organization) and defined the terms of cooperation in all fields.

- The creation of a staff position at the directorate level of the development agency, responsible for improving the linkage between research (commodity as well as FSR) and development.

Main Research Activities

The research program which has been developed (under the above described institutional context) consists of subprograms in the field of animal traction (dry season feeding, training of work oxen, animal health care, improved soil preparation, mechanical weeding and ox carts), better integration of agricultural and livestock activities (fodder crop production, improved corrals, better use of crop residues) and soil conservation (training scheme to be implemented by the village community) (1). These different programs and sub-programs have reached different stages of testing: some of them are still at research stage while others are actually tested at the pre-extension level. Most of the research is carried out by the FSR team, which had an effective number of 12 researchers, whereas some sub-programs are contracted out to other locally competent research institutes. It cannot be sufficiently stressed that the research experience describe herein is very much an iterative process founded on a long-term (often implicit) vision of agricultural development in the area, which emerged from the extensive diagnostic research phase. Research themes

(1) For a detailed description of methodology and results, see DRSPR (1983, 1984, 1985) , and Hallan & Van Campen 1985.

were defined and redefined (1), potential constraints were identified but later on dropped (2) and farm classifications were developed and later on changed when new productive technologies came in sight. In this respect, we largely agree with the views expressed by Cornich and Alberti (1985) who claim that ignorance in an early stage of very important temporal and spatial aspects of the cropping system especially in highly climatic and agro-ecological conditions may lead to an erroneously focussing of on-farm research on a subset of agricultural activities causing a loss of time and ressources and demanding considerable intellectual flexibility to correct priorities.

Being successful in at least some of the research fields, and having opened up fields of collaboration by means of the extension program, institutional linkages with the development agency developed in a positive way. The team became fully accepted as a "knowledgeable" group of person and open-minded debates became possible on previously " sensitive " subjects such as extension methods, diversification and credit programs. This was made possible largely due to a relatively stable research team with minimal personnel turnover.

Thus eventually, research was enriched with a totally new dimension which can be characterized in Norman's terms as a farming systems perspective. In contrast to farming systems research, the FSP activities aim at "influencing the development of relevant policies and support systems" (Norman 1983, p. 3). In this respect, the influence the FSR team had on the organization and financial conditions of a large-scale credit scheme specially aimed at providing work oxen to small farmers, and on establishing a erosion control unit within the institutional structure of the development agency are noteworthy. At this moment discussions are centered on reinforcing the agency's department charged with improving productivity of women's activities.

(1) e.g. in order to make better use of work oxen a research theme was developed around the fabrication of an oxen cart. But after the first prototypes were running, it appeared that the existing donkey carts proved much more practical.

(2) initially, much work was done on internal organizational problems of farm enterprises but later on, this problem lost its priority status as now general solutions could be identified. Attention turned to farm accounting and farm planning.

5. Overview of a Pre-Extension Program

Origin

The pre-extension program had its origins in October 1985, when the development agency confronted the research team in some formal and informal meetings with the problem of how to develop the so-called "backward villages" in the area. These villages can be defined as having a large proportion of farmers cultivating manually, producing a relatively small quantity of the major cash crop and often not, on a village basis, self-sufficent in food production. Reasons for this "backwardness" may differ widely. In some villages, cotton-centered development never took off because of agro-climatic and infrastructural reasons, while in other villages, work oxen were decimated following attacks of trypanosomiasis, forcing people to return to manual cultivation practices. A third cause may be the presence of alternative economic opportunities especially in those villages situated in the more favorable agro-climatic zones and nearby town markets which also presented off-farm employment.

Concentrating on the first two situations both the researchers and development agents agreed on an improved extension program based on the principles of farm classification, group extension and on-farm demonstration. This method, as will be outlined below, was based on a three year experience of the FSR team in two villages and had to be slightly modified.

Content

In a formal meeting (December 1985) chaired by the Director of Research and Extension Coordination of the extension agency and attended by national, regional and sub-regional officials of the development agency, the proposed program was presented. It was discussed in detail with special emphasis on possible constraints in implementation, especially given the work load of the village level extension agents. The comments of the sub-regional agents were particularly helpful as they were the ones closest to the field situation. After hours of fierce debate and several modifications, it was agreed to implement the program in ten villages spread over two of the five regions. Following were the main elements of the program:

- The 10 villages were to be selected by a joint research-development committee on the basis of extensive field visits to a number of villages pre-selected by the sub- regional officers.

- Within these villages, extension efforts were to be focused on two types of farmers. First those farmers who were not using animal traction but meeting the credit criteria (sufficient land and labor resources) for a pair of oxen and a multi-purpose tool bar (type C farmers); secondly those farmers not using animal traction and not meeting the credit criteria (type D farmers). It was assumed that other types of farmers represented only a minor fraction of total farmers.

- Technical package proposed for the two types of farms (1) were:

  . type C: a complete animal traction package including a pair of oxen, a multi-purpose tool bar (both provided on credit), training of oxen, animal health care package, fodder crops and advice for major farm operations.

  . type D: early season hand-hoe based soil preparation on small plots up to 0.5 ha, followed by a strict application of recommended practices (density, fertilizers, etc.) on either cotton or maize or both (farmers' choice).

Implementation

As soon as the memorandum of agreement specifying the responsibility for action at the level of the two regional extension officers for the program was approved by the director general of the development agency, the village identified team began work. From the 10 preselected villages only one village was dropped and replaced, mainly because economic activities in the village were clearly outside the scope of the extension program.

Late in February, training sessions were started for village level extension workers. The training was aimed at the transfer of the details of the new extension program and the mastering of the technical packages proposed in the program. Training was conducted in the village and training sessions were centered around a training program for work-oxen. In each of the two training centers (one per region) there were about 10 pairs of oxen available to be trained by the extension workers according to a 3-week schedule prepared and supervised by the FSR team's animal traction specialist. In the afternoons, classroom sessions were organized around such themes as: group discussions, farm classification, farm planning and a wide range of technical topics.

(1) Types A and B refer respectively to fully equipped and partlyequipped ox-draught farmers.

It was found particularly fruitful to combine practical training on technical topics with classroom sessions on more abstract topics. Considering the rather straightforward and practical attitude of these extension workers, it might otherwise have been impossible to keep them for three weeks.

At the end of March, a series of villages meetings were organized in each of the 10 villages. The purpose of these meetings was to discuss candidly farmer's perception of agriculture, progress and related issues. First, meetings were held with the whole farm community and later on with sub-groups consisting of those farmers belonging to the same category. In all, there were three consecutive meetings in each village. The first village level meeting was presided by the regional extension officer and included, apart from the village community, the sub-regional officers, the complete group of village extension workers and two members of the FSR team. This meeting served as a kind of on-the-job training for the village extension workers who had to conduct the same type of meetings in their respective villages without outside assistance.

The last two village meetings in the series served also to invite farmers on a voluntary basis, to adopt either type C or type D technology packages. As was expected, response was overwhelming in the case of the animal traction program whereas enthusiasm was only modest for the non-animal traction program. However in each of the 10 villages at least two farmers (1) presented themselves for the latter program. The number of farmers participating in the animal traction program had to be limited to the total number of oxen available (2) for the credit scheme, i.e. eighty (80). By organizing regularly farmers' visits to the fields of category D farmers, we hope to boost participation rate in the non-animal traction program in subsequent years.

In April just before the onset of the rainy season, technical implementation of the program began with the three-week oxen training program in each of the 10 villages, supervised by the village extension worker himself. FSR team specialists limited their assistance to one post-training visit (to inspect the site, animals, stables, etc.) and two or three visits during the course of the training period. In all, about 8 to 16 farmers per village were trained in handling their newly obtained animals and equipment.

(1) per village there are about 15 to 40 farm families

(2) availability of work oxen is a major constraints in some areas

At about the same time the program for farmers with no animal traction was initiated by the demarcation of the plots and later on by demonstrations of line sowing techniques and application of recommended densities.

Monitoring

In each village, 4 farms were selected (two of each farm type) to be monitored closely by the extension worker. Simple data collection forms were developed to record essential data e.g.: method and date of land preparation, sowing dates, input use, etc. The purpose of this part was to encourage the extension worker to take an interest in day-to-day management of the farm technology thereby developing a whole farm perspective instead of the usual sectoral view towards different enterprises on a farm. At the end of the season these data were used in training sessions on farm planning and credit worthiness ratings.

Throughout the cropping season, FSR team visited the farms twice a month on an average, although at the beginning of the season visits were somewhat more frequent. Whenever possible these visits included sub-regional officers or their staff. The FSR team member acted mainly as a counselor to the extension worker promoting discussions on technical issues and farm management decisions.

Discussion

As this pre-extension program is still in its operating phase, no results in terms of yields or production are yet available. Final conclusions will be drawn only after extensive field trips and discussions with the Development Agency. However, regular discussions with the 8 regional agents, 18 village extension workers and about 100 farmers involved in the program indicate an overall positive picture, with some aspects in need of reconsideration. These points, actually "hot topics" in the research team, are enumerated below:

- to what extent two different technical packages, requiring different degrees of institutional support and resulting in different production impacts should be extended in the same village? Does this create problems (e.g., tensions) between farmers?

- is it worthwhile initiating a program with open-ended discussions with the whole farm community, while concentrating on a limited number of farmers with two sets of technical packages? Should actions responding to the village community as a whole be an integral part of the program?

- to what extent the FSR team should intervene in the support services system? (it has been observed that seemingly trivial facts can dis-proportionately affect the efficient implementation of the program and the positive outcome).

- motivation of the village extension worker remains a problem; for him the program means simply extra work not compensated with any tangible benefits. What can be done about this?

Future modifications in the program will focus on some or all of these points. FSR should offer improved technologies suitable for all four types of farms in these villages. In our view, the pre-extension program occupies an essential final stage of the FSR chain, permitting FSR teams to verify how technologies perform under farm and institutional constraints.

6. Conclusions

The difficult and vital problem of the transfer of research results from research to development agencies and to farmers seems to have found an appropriate solution in the case of "Mali-Sud", by the creation of a common platform called "pre-extension", enabling both research and extension agencies to work together in the same place, with the same farmers, on the same problems. Among the factors which have contributed to these achievements were: the existence of an efficient, well established development agency, the adoption of research policy and agenda appropriate to the needs of extension agency, and the choice of a down-stream FSR approach and the acceptance by FSR team members to keep a low profile until certain technological improvements could be offered.

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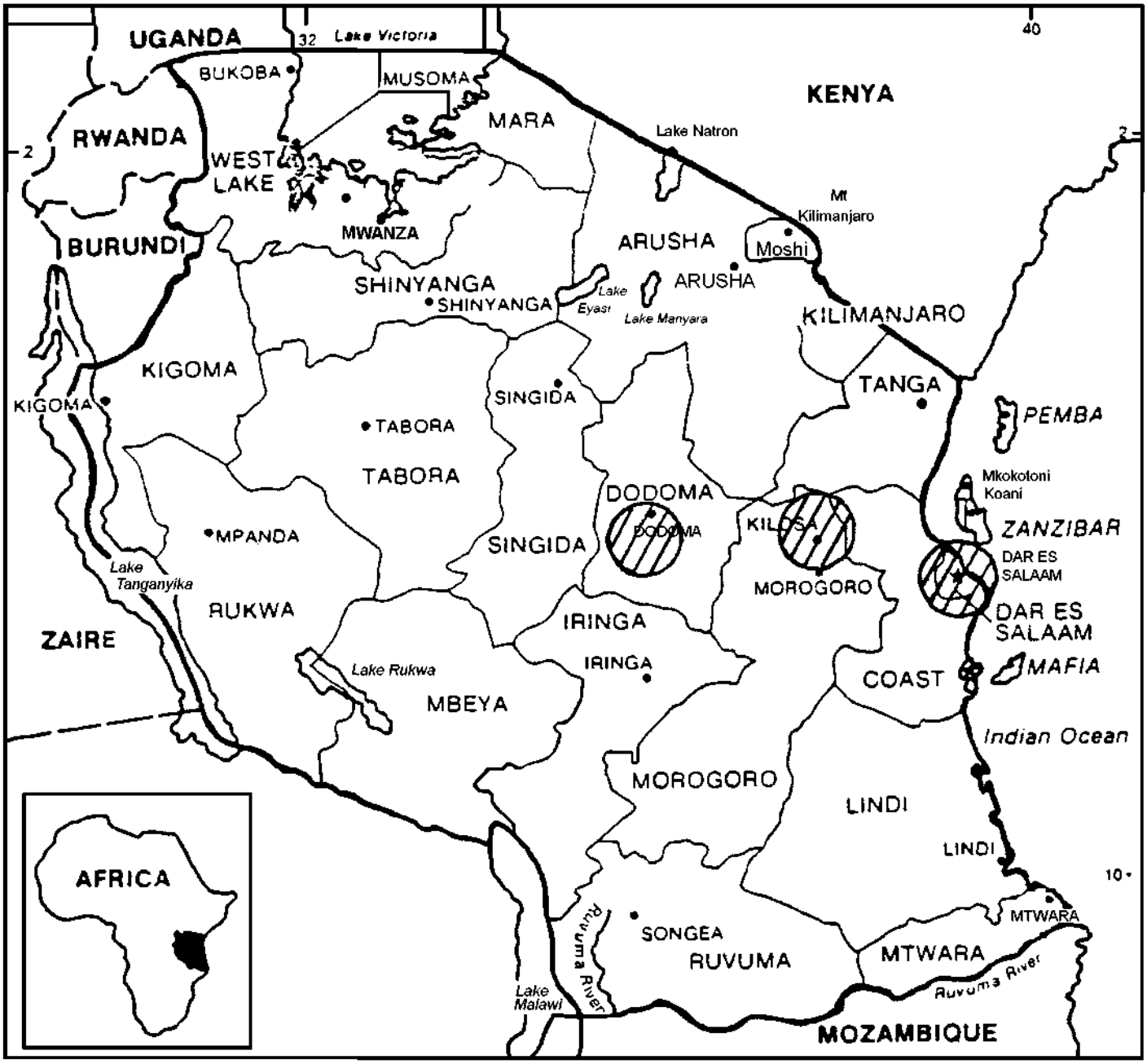
A STUDY OF THE ROLE OF EXTENSION IN FARMING SYSTEMS RESEARCH IN TANZANIA



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INTRODUCTION

This report summarizes a September 1985 study on the role of extension in farming systems research in Tanzania conducted by Mr. Don Sungusia, Research Extension Liaison Officer, Tanzania Agricultural Research Organization, an Mr. David G. Acker, Project Director, Tanzania Farming Systems Research Project, Oregon State University.

The idea for this study arose through the Tanzania Farming Systems Research Project Annual Project Review (June 1985), which found that although extension personnel involvement was essential to the successful implementation of a farming systems research approach, there was no clear direction for the involvement of extension in future farming system research efforts. This study attempted to clarify the role extension can play in a farming systems research approach to technology generation and development and to estimate the resources required as extension assumes such a role.

It is important to note that the study was limited to collecting the perceptions of extension professionals. Thus the study serves to highlight the potential contribution of the extension organization as perceived by extension practitioners. As such, the usefulness of the study lies in its exploration of the variety and nature of supporting roles extension can play as it becomes integrated in the farming systems research process.

PROJECT BACKGROUND

The Tanzania Farming Systems Research Project is administered and supported by the Tanzania Agricultural Research Organization (TARO) with external financial support from the United States Agency for International Development (USAID). Technical assistance is provided by the Consortium for International Development with Oregon State University serving as lead university for the consortium.

Specifically, the purpose of the Tanzania Farming Systems Research Project is to improve the availability and use of basic food crops research through:

1) Introduction of a farming systems research approach characterized by: (a) the inclusion of farmers along with researchers and extension workers as active participants in an interactive and incremental process of identifying, prioritizing, testing and evaluating agricultural research on a continuing basis;

(b) research that is directed toward the development of technologies which are farmer and location specific and which meet high priority needs and acceptance by farmers; and

(c) a research process that is near-term and cost-effective in design;

2) Provision of management assistance to TARO in its organization, operation, oversight, control and planning functions to enhance its capability to conduct and sustain adaptive research expanded to a national scale; and

3) Provision of encouragement and assistance to TARO, the Divisions of Research, and Extension and Technical Services, and other research and extension units and agencies to work cooperatively toward the development of common goals and objectives to enhance Tanzanian agriculture and toward the implementation of the goals and objectives established.

PROBLEM STATEMENT

The Tanzania Farming Systems Research Project, as set forth in the statement of purpose, was designed to be a cooperative effort among researcher, extensionist, and farmer in the process of technology generation and transfer. The statement of purpose suggests that the importance of extension had been recognized during the project design process.

However, in spite of this recognition, the project was launched with its base of operations solidly grounded in the research organization and with no formal agreement with the extension service as to how joint collaboration on technology development and transfer was to be made operational. Project resources and funding were not available to support extension involvement in farming

systems research work. Furthermore, extension personnel were not assigned to farming systems research teams.

The phenomenon of placing distance between farming systems research work and the extension service is not without precedent in Tanzania. A noteworthy example was found in the farming systems research effort at the Sokoine University of Agriculture in which University researchers utilized research assistants to perform village-based diagnostic work instead of utilizing existing village-based personnel. Given that research and extension are inter related components of the same process of technology development and dissemination, it can be argued that it is essential for farming systems research projects to involve indigenous organizations performing both of these functions.

Aside from the philosophical basis for supporting this idea, there are also practical considerations of cost and effectiveness. TARO and other agricultural research organizations in developing countries often operate without adequate manpower, funds, and equipment to launch and sustain a program of on-farm applied and adaptive research in large sparsely populated areas far from research institutes. If farming systems research is to be accepted under these conditions, it must be proven to be cost-effective in generating and transferring new technologies. The extension service can play a key role in improving the cost-effectiveness of technology development and transfer through utilization of its trained village-based personnel.

Consideration must also be given to the ability of research to generate and deliver appropriate technologies to farmers. Researchers, often inexperienced in dealing with farmers' problems, may inadvertently cause research priorities to be inconsistent with farmers' needs. The extension worker serving as a screening agent can help prevent the generation of such inappropriate technologies.

OBJECTIVES

The purpose of this study was to investigate the potential for increased extension service participation in farming systems research as a means for improving the cost effectiveness and relevancy of technology development and

dissemination of that information for limited resource farmers in Tanzania.

The study had the following specific objectives:

1) to review related literature and summarize recommendations made by previous researchers and study teams on the role and structure of extension in agricultural research;

2) to assess the potential value of increased involvement of the extension service in farming systems research;

3) to explore programming options appropriate to existing organizational structures for integrating extension and research in the process of technology development and dissemination;

4) to present the findings of this study in the form of a report, including the literature review, a summary of interview responses, and a needs assessment for extension service involvement in future farming systems research, (i.e. training requirements for extension workers, proposed organizational relationships, and models for interagency cooperation);

5) to lay groundwork for future farming systems research program planning by showing that greater synergism, reduced cost, and improved program performance can be achieved through increased involvement of extension personnel in farming systems research; and

6) to identify topics and issues requiring future research.

METHODOLOGY

The authors of this study utilized both primary and secondary sources in their investigation. Interviews with six extension and four training professionals supplied primary data, while a review of project documents and selected papers provided a source of both secondary data and general background material.

Interviewees were purposefully selected for their working knowledge of farming systems research, as well, as their experience in extension and training. Interviewees were selected in consultation with extension officers in Tanzania. Interviews were conducted in Dar es Salaam, Morogoro, Kilosa, and Dodoma. Extension personnel at national, regional and district levels were interviewed. They have all been involved, to some degree, in work on the project.

A topical questionnaire in outline format was used to guide interviews (Appendix A). Topics were introduced in an open-ended question format by the active interviewer on the two-person study team. Responses to these open-ended discussion questions were recorded in brief during the interview by the passive interviewer then recorded in greater detail after the interview. Interview notes were reviewed by both interviewers. Each interview averaged approximately 75 minutes.

Several questions required that interviewer and interviewee have a common understanding of the phases of farming systems research approach. To facilitate this common understanding, a handout was provided to the interviewee for his review prior to responding to questions (Appendix B). This ensured that interviewee and interviewer both referred to the same phases of farming systems research and in the same order. The handout was based on David Norman's (1982) "Schematic Framework for Farming Systems Research" (Appendix C).

Data was cooperatively analyzed by the study team upon return to Dar es Salaam. Based on the study's findings, this report was developed to serve as a working paper for future farming systems research planning efforts. Twelve copies of the report were circulated in draft form for comment in October 1985. Comments were incorporated into the final version prepared in December 1985.

REVIEW OF RELATED LITERATURE

One objective of the study was to review recommendations reported by previous researchers and study teams on the role and structure of extension services relative to agricultural research. The review is organized under the following headings:

- Research Deficiencies
- The Role of Adaptive Research
- The Role of Extension Workers in Technology Development, Adaptation, and Dissemination
- Research Extension Liaison
- Logistics

- Summary

Research Deficiencies

To date, the effects of agricultural research efforts have fallen short of original expectations. While it is clear that research-based agricultural technologies are a key ingredient in the process of increasing food production, it is evident that these technologies have varied tremendously in their appropriateness for acceptance by small farmers.

Some of the shortcomings of current agricultural research programs have been described by CIMMYT economist M. Collinson, who argues that the technical perspective of agricultural problems manifests itself in research recommendations which are unfinished products, in three closely related ways:

1) farmers never use a purely technical perspective in managing their farms and consequently, never use it in evaluating new technologies introduced to them by the extension service;

2) recommendations inevitably take the form of 'final solutions'-the best way to produce. Farmer markets may only be willing and able to handle intermediate or partial solutions due both to the managerial (systems) perspective they use and to their limited resource endowments; and

3) recommendations are made on a 'blanket basis', at best for a specific agro-ecological zone. This fails to recognize that economic circumstances dictate farmers decisions and modify, often dramatically, these agro-ecological influences. (Collinson, undated)

More serious, however, is the general research deficiency in Tanzania. The National Agricultural Policy final report (1983) by the Presidential Task Force had the following to say:

The current situation in agricultural research is that, apart from the serious research efforts being made at the Wheat Research Station in Arusha and at the Uyole Agricutural Centre, there is virtually no research activity being undertaken in all the other stations. The following factors contribute to this unsatisfactory situation:

a) Lack of policy direction in research
b) Non-availability of competent researchers
c) Insufficient funds to meet both recurrent and development expenditure
d) Inadequate transport to supervise field trials
e) Ineffective coordination between research bodies
f) Absence of research - extension linkages
g) Inadequate research facilities
h) Emphasis on station-based research, vis-a-vis farm based research

The Role of Adaptive Research

On-farm trials (OFT) or on-farm research (OFR) are used by researchers to test and adapt technology developed on research stations and to verify its feasibility under actual farm management conditions.

> On-Farm Research finishes the research product under the conditions farmers will expose it to when they adopt recommendations coming out of the OFR programme. The Farming Systems Perspective (FSP) identifies farmers' most important problems and best expansion opportunities, and the appropriate technology to solve those problems and better exploit those opportunities. By this process, it focuses extension on to recommendations most likely to be rapidly absorbed by local farmers, enhancing the cost effectiveness of research and extension efforts. (Collinson, undated)

Collinson adds that on-farm trials also have implications for extension proramming by bringing researchers, extensionists and farmers into contact in local specific farm situations, and drawing extension staff into the

technology 'finishing' process thereby removing the research/farmer and the research/extension linkage problems. Through involvement in this process, extension is able to have input on decisions in both the evolution of the experimental programs, as well as, decisions on the context of farmers recommendations. Furthermore, extension can become familiar with the management requirements of emerging recommendations and their implications for input supply, credit and extension training.

According to Collinson, once the farmer-managed verification trial stage is reached, major aims are:

- to test robustness across the variability of the (research) domain; and
- to draw extension staff into the trial programme and pre-educate them on likely recommendations. (Collinson, undated)

The Role of the Extension Worker in Technology Development, Adaptation and Dissemination

The process of technology development, adaptation and dissemination is essentially farmer centered or client based. As such, each objective of the process is focused on the end user of the results. However, in practice, this process has often strayed from the tenets of the school of "management by results."

As J. deJong (1983) notes, there is a tendency towards conducting system research without actually involving the local population. The phrase "about them, but without them" seems most appropriate. Many needs have been "identified" and solutions would undoubtedly be of benefit to local populations, but for the lack of involvement.

Early participation of extension workers in the process of technological development is of paramount importance. When as many extension workers, as possible, are involved in the final trial stages, they are able to identify with 'their' recommendations and not feel technology is being dumped on them subsequently to sell to the farmers. Collinson notes that extension workers are in a good position to tell researchers whether or not all the farmers in a

village have the means to adopt a technological package which requires purchased inputs.

> Village extension workers play the following roles in the adaptation and dissemination of new technologies:
>
> a) Organize farmer meetings to discuss the OFR/FSP programme with the community;
> b) Organize the farm visit programme of the OFR/FSP team during the diagnostic survey;
> c) Interpret at farmer interviews for the OFR/FSP team, where necessary;
> d) Help in the identification of farmers as hosts for on-farm experimentation;
> e) Help in laying out the experiments, routine recording and the supervision of treatment management; and
> f) Organize farmers groups, researchers and senior extension staff in meetings on experimental sites to assess the treatment being investigated. (Collinson, undated)

To most effectively develop and adapt new technology, Collinson suggests that researcher-managed on-farm trials be managed by field trials officers, and that farmer-managed verification trials be conducted by farmers with close involvement by extension staff. According to Collinson,

> . . .the continual interaction between farmers, researchers and extension staff allows a prompt consensus when improved technology is ready for dissemination. The most obvious sign is host farmers beginning to use experimental techniques on their own crops and animals. Extension staff, who have been involved with the On-Farm Research progamme, have an intimate knowledge of the managerial implications of the new techniques, as well as, the ability to lay down demonstrations on farmer fields and to widen exposure to the interventions across the community. Two points should be emphasized about the approach described. First, extension staff have a great deal of confidence in recommendations developed in this participatory way

> on local farms, Second, the approach pulls down whatever technology is diagnosed as appropriate into local farm situations. This is the major difference from current, pushing of technologies at farmers, regardless of the specifics of their local situation. (Collinson, undated)

However, Collinson cautions that extension work loads must be adjusted to reflect additional farming systems research responsibilities and that this adjustment requires agreement/endorsement from the top leadership in extension.

> The senior agricultural professional in a region will normally be a member of the local planning body. As such, he will probably have a significant influence on and certainly be party to decisions on priority target groups for OFR/FSP initiatives. As a result of these decisions, he will initiate modifications to work plans and budgets for his staff in the areas of the selected target groups to coordinate activities with the OFR/FSP team(s). (Collinson, undated)

De Jong (1983) also cautions that extension workers need training in these responsibilities. In-service training must be directed at the concerned extension worker so that he may adapt what he has learned to local conditions. Training must be practical with emphasis on the use of appropriate techniques and how to modify inputs for those cultivators who lack the necessary equipment.

Research Extension Liaison

Organizational gaps are not uncommon within government establishments which are assigned to various components of the technology development and transfer process. One of the most common gaps is found between research (technology development) and extension (technology application). The problem is often embedded in the organization's perceived mission. For example, if research sees its role as that of simple technology development but with no responsibility for technology transfer, then research results may never leave the circle in which they are produced. Likewise, extension may perceive its mission as one which begins with an appropriate technology being delivered to

its door for onward transmission to farmers.

To further exacerbate the situation, the function of technology adaptation is more often than not seen by both research and extension as extraneous to their mission. As a consequence, research recommendations of questionable utility to farmers are lodged in annual reports of the various research stations and extension ends up waiting for recommendations which never come.

A popularly supported remedy to this situation may be in establishing a position, in either the research or extension organization, charged with creating organizational linkages. This position would have the express purpose of expediting the flow of technical recommendations from research to extension and for ensuring that problems uncovered by extension are reported back to the research organization. Along these lines, a mission from the Food and Agriculture Organization of the United Nations recommended the establishment of a research extension liaison unit.

> A research liaison unit should be established in the new extension service and research liaison officers appointed to all major stations. They should ensure that research results are translate into recommendations for the presentations to farmers. (FAO/UNDP, 1982)

More recently, the "Interim Report of the Task Force to Review Organizational Structure for the Research and Training in Agricultural and Livestock Development" (1984) supported the need for such a function. However, contrary to the suggestion of the FAO mission, the task force suggested that such a function be established and controlled by the research organizations.

> This task force calls for the recruitment and posting of senior officers to staff Research Extension Liaison Officer posts at national and institutes levels. These officers would be charged with maintaining the flow of field problems from RADOs to researchers and the flow of current research findings from the institutes to extension agencies.

Officially, channels exist under the present organizational structure for research and extension to communicate. However, as Tibaijuka contends, this system is not without flaws as is seen within KILIMO where the overall responsibility to set research priorities and coordinate research programmes is conducted by Crop Coordinating Committees, These committees have an overall responsibility to review past and ongoing research projects and formulate recommendations and priorities for the future. Membership is composed of senior researchers from research institutes, the Sokoine University of Agriculture, and the national research organizations working with the respective crops or programmes in question. The denial of voting rights to the representatives of the extension system (i.e., RADOs) reflects the overlooking of the views of extension workers on research which in turn breeds irrelevance. (Tibaijuka, 1985)

Logistics

Farming systems research programs have to contend with the realities of human, bureaucratic and geographic limitations. Contact with extension workers varies with the distance between a household and the nearest extension worker station. In Zimbabwe, deJong (1983) notes that the majority of households (58%) receiving extension advice live within four (4) km of an extension worker. This indicates the need for a suitable form of transport to enable extension workers to service the needs of outlying villages.

Regarding costs of conducting on-farm research, Collinson states it is recognized that the transport and travel requirements of the professionals involved in OFR/FSP will be equal to those of extension professionals, and certainly higher than transport and travel needs of commodity researchers. On the other hand, station maintenance votes absorb a significant proportion of commodity research budgets, but are not needed for On Farm Research.

SURVEY RESULTS

The survey consisted of 10 semi-structured interviews conducted during September 1985. Open-ended questions produced comments that lend themselves better to narrative summaries than to quantitive analysis. The following is a summary of results organized by question.

1) What is your opinion of farming systems research as an approach to developing and delivering new technologies to farmers?

Respondents expressed a high opinion of farming systems research as an approach to developing and delivering new technologies to farmers. Responses illustrating the reasons for their opinion include:

- the farming systems research approach helps to remove both extension workers and researchers from their perception capsules;

- technology recommendations developed through farming systems research are based on actual farmers problems and are thus more appropriate to farmers needs; and

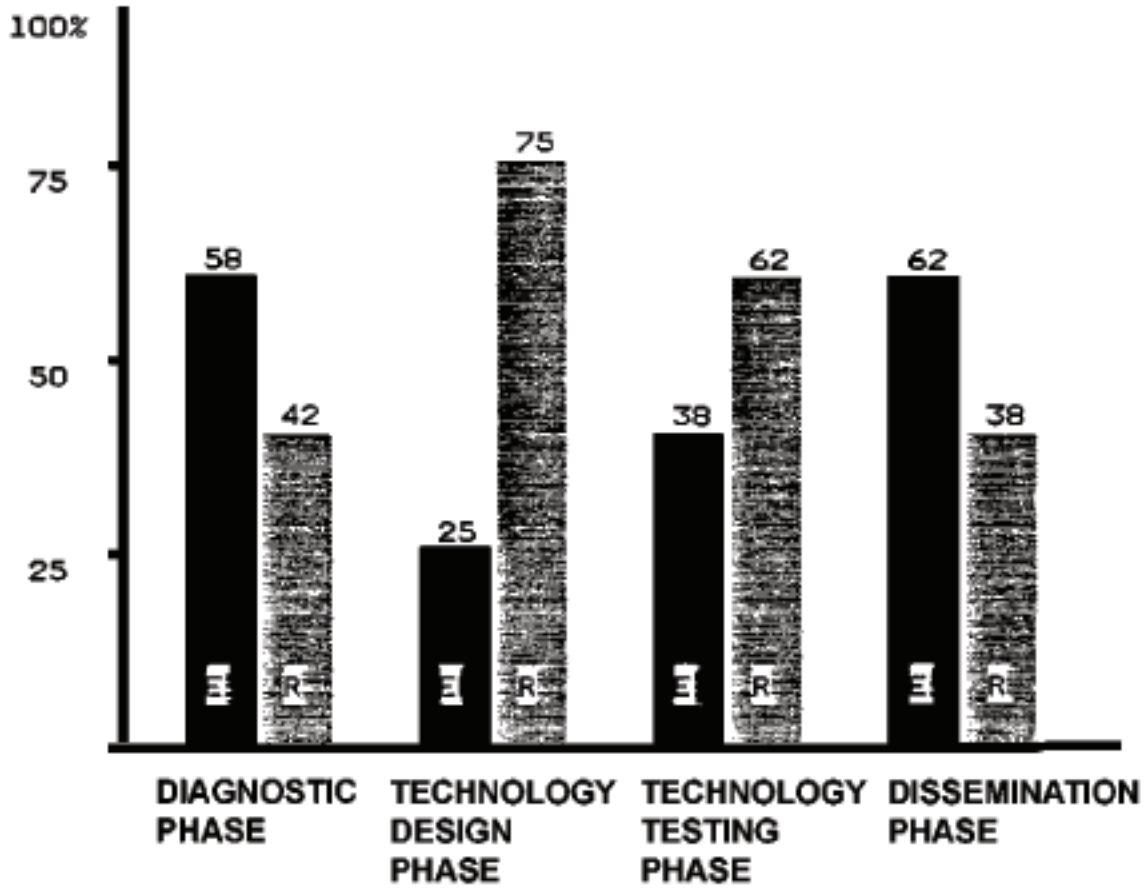
- recommendations are developed in a participatory manner involving farmers, extension workers and researchers as a problem solving team.

2) What do you see as the role of extension in each stage of FSR?

Figure 1 summarizes how extension professionals view the relative importance of the extension and research roles in the four phases of farming systems research and extension.

Figure 1:

Relative importance of roles of extension and research in the process of technology development, adaptation and application as expressed by extension professionals.



E=EXTENSION
R=RESEARCH

The Relationship Between Farming Systems Research and Commodity Research Programs: A Case Study from the Tanzanian Farming Systems Project

Larry S. Lev*

INTRODUCTION

In Tanzania, as in many other African countries, Farming Systems Research (FSR) represents a recent addition to existing commodity research programs. This report summarizes the relationship which has developed between the FSR teams and the commodity researchers over the three-year life span of the USAID-sponsored FSR project within the Tanzanian Agricultural Research Organization (TARO). The performance of the Tanzanian agricultural sector has been poor in recent years with food crop production unable to keep up with the population growth rate and cash crop production, in many instances, falling blame. The authors of "The Tanzania National Agricultural Policy" (1982, p.44) bleakly noted:

> The current situation in agricultural research is that, apart from the serious research efforts being made at the Wheat Research station in Arusha and at Uyole Agricultural Centre, there is virtually no research activity being undertake in all the other stations.

A simple increase in the resources devoted to agricultural research is not viewed as sufficient since there is the concern that much of the research is not relevant to the majority of the rural population. The suggested solution has been to re-direct agricultural research efforts toward problem solving, farm-based research. Farming systems research provides a methodology to achieve this goal.

Even while the popularity of FSR has been on the rise, some practitioners have cautioned lest it be oversold and have argued that the credibility of the approach much be built up slowly (Norman and Baker, 1984, p.1). Still others believe that the pendulum has swung too far in the direction of applied research and thus that:

> ....In the year 2000, when agricultural historians look back at African agriculture in the last third of the century, they will probably conclude the donors erred in committing too many resources to applied research (for example, farming systems research) in the IARCs and national research services and too few commodity research and basic science research in support of agriculture (Eicher, 1986, p.11).

Thus, in countries such as Tanzania where FSR is still in its infancy, it is of critical importance to build the program slowly but surely.

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From the beginning of the USAID project, we identified the TARO commodity researchers as our highest priority target group since they are the people that the FSR teams must rely on most heavily for technical support. As a result, in addition to focusing on the recruiting and training of personnel for the FSR section, we established a second hidden agenda of "infecting the conducted commodity researchers with the FSR virus" and thereby changing the way they conducted their own research.

This paper discusses out experience in the area. As the newest section in TARO, we wanted to fully display the advantages of the FSR approach without forgetting that the commodity sections were staffed by better trained and more experience researchers. Over the last three years we have held many informal discussions with commodity researchers to assess their views. In addition, a formal assessment exercise was conducted during the final project conference when twelve senior commodity researchers, who were most familiar with project activities, were questioned about heir attitude towards FSR (the questionnaire and a summary of answers are presented in the appendix).

THEORY: TYPES OF RESEARCH

Johnson (1982) defines three fundamentally different types of research:

1. Disciplinary research- this is research which is designed to improve a particular discipline and maybe of known or unknown relevance.

2. Subject matter research- this is multidisciplinary research Which is of interest to a set of decision makers and addresses a set of problems. Ordinarily, the research is not sufficient to solve and given problem.

3. Problem solving research- this research addresses a specific problem and seeks to provide a solution for a specific group of decision makers.

Most commodity research falls under the category of subject matter research since it seeks to provide information for a broad spectrum of decision makers, but generally does not provide a complete answer to any one group of decision makers. In contrast, the nature of the FSR process requires that the target group and problem must be identified, which implies that the adaptive research teams are further along the spectrum towards problem solving research. By way of comparison, extension is not viewed as serving a research function since, instead of attempting to solve problems, extension personnel are seen as dissemination already formulated solutions.

The real strength of the FSR teams is that they can form the linkage pint between the subject matter research of the commodity researchers and the dissemination activities of extension. The end result is a technology generation and dissemination process built upon the joint work of all these groups.

HISTORY OF THE PROJECT

USAID/IITA sponsored a food crop research program. From 1973 to 1982, during the final project review, the suggestion was made and accepted that the next phase of the research should include a FSR component. Although initially designed as a massive effort (75 man years and twenty million dollars for the first five years of the project), the scale of the project dwindled as relations between the U.S. and Tanzania soured. In final terms, the Project provided eight man years of technical assistance and 2.225 million dollars over its effective three-year life. The small scale, although certainly not the short time span of the Project, has had its advantages since the FSR teams were able to approach the commodity researchers a junior partners rather than as threatening rival. This small project simply has not controlled enough resources to generate much jealously.

ORGANIZATION OF AGRICULTURAL RESEARCH IN TANZANIA

The recent history of agricultural research and extension has been marked by several major changes. In 1974, crop research in Tanzania was reorganized along commodity lines with national coordinator for each major crop. A second major change occurred in 1981 when agricultural research was taken out of the Ministry and divided among four separate parastatals: the Tanzanian Agricultural Research Organization (TPRO, the Uyole Agricultural Centre (UAC), the Tropical Pesticides Research Institute (TPRI), and the Tanzanian Livestock Research Institute (TLRI). Although the three-crop oriented parastatals have overlapping mandates, they seldom interact. Extension, the other major actor in the agricultural sector, was for quite some time handled out of the Prime Minister’s Office and was only returned to the Ministry in 1983. It does not and has not had effective links with research. In fact, in order to exchange information, it is necessary for the communication to travel from the localities all the way to the capital and back again. TARO, the largest of the parastatals, controls eleven research stations and is responsible for conduction research on fifteen different commodities. As of June 1986, TARO had a total professional staff of 143 which include 200 expatriates an 25 officers on study leave. Since its inception in 1981, it has been primarily made up of biological scientists and of the current in-country staff, only 3 of the 98 professionals are social scientists (all are agricultural economists). A slightly higher percentage, 4 of 25 (16%) of those on study leave are social scientists.

This staffing pattern leaves ARO ill-equipped to carry out many forms of adaptive research. The shortage of social scientists is exacerbated by the lack of ties to other institutions who could provide this expertise.

MANDATE

The USAID FSR Project was superimposed onto this situation. FSR is not new in Tanzania. Similar efforts were on-going at the University, at the UAC, and in various regional development programs. Even TARO had an aborted effort as part of the previous, mostly commodity based Agricultural Research Project. In establishing a new FSR program within there were at least

three alternative organizational structures (which are the same as those cited by Kean, 1985 for Zambia). The first alternative was to completely re-organize research along regional lines and have commodity and adaptive researchers work together for the solution of regional problems. This type of change was mandated in the 1982 Agriculture Policy but has not been implemented to date. The second option was the integration of social scientists (and hence a FSR component) into each of the commodity programs. This would have required more manpower than was available and may have resulted in the isolation of the social scientist within each commodity program. The third option, which has been the one adopted, maintained the commodity groups with their national focus and superimposed zonal FSR teams at two agricultural research stations as a pilot activity.

Thus, in terms of mandate, there is a clear difference in focus between these new regional programs and the traditional national crop focus. This difference in focus has significant implications for the types of linkages which are formed with other groups including extension and local political units.

PERSONNEL

When the project started, there was a reluctance to assign full-time personnel to staff the section and perhaps the feeling that these activities could be carried out on a part-time basis. The initial personnel provided to the section were field trials officers (holders of diplomas in agriculture). Three years into the farming systems effort, the FSR section in TARO is made up of six scientific officers and seven field trials officers. The scientific officers are divided equally between biological scientists and social scientists and are also divided equally between those who joined the program directly from the completion of their first degree and those who were transferred in from other activities.

Based upon our recent survey, the general attitude towards the FSR approach among TARO personnel has changed considerably over the three years of the projects. When asked to rank their knowledge of FSR now as compared to three years ago using a one (low) to five (high) scale, the respondents indicated an increase from 1.4 to 4.0. This increase in knowledge was accompanied by an increase in appreciation for 92% of the respondents. Currently, 58% of the respondents characterized themselves as “mildly supportive” of the approach. Still, only half of the respondents indicated that the FSR teams have has an influence on their own work.

Interestingly, despite these positive attitudes toward FSR, only one of the twelve respondents (8%) indicated a willingness to be transferred into a FSR team on a full-time basis. The reasons for this reluctance were two-fold. First, the vast majority of the commodity researchers feel that their skills are better used in their current positions. Secondly, there was a pragmatic concern expressed by some of the researchers about the future of FSR and, therefore, its security as a career option.

Our experience has been that field trials officers and social scientists are the easiest to attract to the FSR section. Neither group undergoes academic training which rewards increasing specialization. If trained technical scientists are to be recruited into the FSR section, their training and opportunities for professional advancement will have to be substantially altered. As will be detailed in later sections, it is evident that only a portion of the FSR message has gotten across to the commodity researchers. Until a better selling job is done, it will remain difficult to attract new personnel into the section.

Many of the respondents noted that the FSR team members have been overly critical of the work carried out by the commodity research programs. This is a delicate and important concern since on the one hand it is necessary to point out the differences, but on the other hand, this much be done in a tactful manner.

RESEARCH PRIORITIES/DIAGNOSIS

In a world of limited research resources, the settling of priorities is perhaps the most important undertaking. It is in the area that a key difference arises between the commodity groups and the FSR section. Overall there is no clear mechanism for setting priorities and allocation funds among programs within the intermittent and largely unpredictable support provide by foreign donors for specific programs.

Within each individual crop program, that national coordinator sets priorities which are ratified by the coordinating committee which meets only once a year to review research proposals. In turn, each crop program is subdivided into three or four subprograms and those subprogram leaders have considerable freedom to define their own research interests. The result is a very decentralized decision-making process with little control over the direction which the research takes. Each individual researcher sets his/her own objectives which generally is the maximization of one particular element such a yield with little regard for other factors such as labor, timing, or even cost.

The setting of priorities within the FSR program stands in marked contrast. The first stage, the selection of target areas, is little different since they are selected based upon arbitrary criteria. Within those areas, however, research priorities are set in a clear fashion based upon initial diagnosis of the system an inventory of relevant available technologies (CIMMYT, Manual 14). In Tanzania, as I am sure is true elsewhere, this is modified to take into account the interest and expertise of the team. Thus, in Tanzania we have not focused on livestock or grain storage issues simply due to lack of expertise.

In our survey of attitudes toward FSR, the diagnostic stage and the setting of research priorities were cited as the most attractive attributes of the FSR approach. The addition of the farmer’s perspective through an integration of social and biological sciences represents a new approach for a many of these researches.

An example of differing research priorities is demonstrated by what we have termed the “Kito Story.” The National Maize Program identified maize streak virus as the major cause of reduced maize yields in Kilosa District and set the development of resistant varieties as a major objective of the breeding program. The FSR team, however, discovered that local farmers grew the majority of their maize during the short rains because they were most concerned with obtaining an early harvest thereby reducing their overall risks and freeing up land and labor later on for other crops. While on the research station, the maize program had developed an open pollinated 90-day variety, Kito. It had received little attention because of its lower yield potential and small ear size. The FSR put together the farmer together the farmer priority and the existing technology and proposed the intervention of replacing existing maize varieties with Kito to be grown during the short rains. The results have been remarkable as this intervention has quickly been adopted by all farmers who have access to the seed. Based upon the success of Kito, a whole new series of research opportunities focusing on sequential cropping patterns has been opened up for both the FSR and commodity sections. Our experience with farmer reaction to new cowpea varieties presents a sharp contrast. Whereas the breeders have put a great deal of effort into developing 60-day cowpea varieties, farmers have largely ignored these new varieties. With cowpeas, they are primarily concerned with grain type and color, not maturity.

We remain convinced that the well-informed commodity researchers should actively participate in the off-station aspects of the diagnostic process rather than merely receive and comment on FSR team reports. Once the commodity researchers enter into discussions with farmers, they will quickly understand that complex systems already exist outside the fences of the research station and instead of seeking to design new technologies from scratch, they will focus on improving existing practices.

EXPERIMENTAL METHODS

Beyond the diagnosis and setting of priorities, there are other differences between the FSR and commodity research teams. Whereas experiments within the commodity programs are often planned, monitored, and evaluated by individual scientists, within the FSR teams there is a great deal more interaction. All scientists and fields trials officers in a given zone participate in frequent planning sessions and all have some input during team meeting on monitoring and evaluation. The FSR team members are forced to develop as generalists.

The location of experiments also varies somewhat between the FSR and commodity teams. Currently in Tanzania we have considerable overlap and have not decided what we will do about it. In addition to working on farmers’ fields, the FSR team carries out on-station trials using in general, fewer inputs, planting at a different time, and often varying plot size. The commodity group conduct off station trials under much more tightly controlled circumstances and give less weight to farmer assessment.

In our survey of attitudes, no firm consensus was reached as slight majorities (58%) favored the continuation of FSR on-station experiments

and opposed the continuation of commodity program village experiments. All respondent would certainly prefer that the FST people concentrate on the farm and commodity researchers on the research station, but recognize that this dividing line need not be hard and fast as long as good communication is maintained. One of our most effective strategies has been the joint management of on-station experiments between FSR and commodity groups which has carried out for all of the major food crops and cotton.

In the area of experimental methods, many of the commodity researchers expressed concern with the level of technical expertise of the FSR staff. In one respect, this justified since the FSR scientists are more junior and hence, less experienced. In a second respect, however, this reflects their lack of familiarity with on-farm research techniques. We were quite surprised in our survey that none of the twelve respondents mentioned the experimentation phase of FSR as a primary attribute of the process. In contrast, the FSR team members highlight the continued learning which occurs from carrying out experiments with the active participation of farmers. Most of our current experiments are based on farmer comments and on modifications of earlier on-farm trials.

RELATIONS TO OTHER INSTITUTIONS

As we noted earlier, virtually no direct communication was occurring between research and extension personnel at the beginning of the project. Neither commodity researchers nor extension personnel viewed it as a part of their primary responsibilities. The FSR teams have shown themselves to be capable of communicating with both groups and have shown promise in acting as a catalyst for developing direct lines of communications between the two groups.

The FSR teams have also opened up new lines of communication with input suppliers such as the seed farms. Traditionally the commodity researchers interacted with the seed farms only as a supplier of breeder seed. The FSR teams, in contrast, provide feedback as well as demand for output. A good example of this has been the interaction over the issue of providing Kito seed. The normal operating procedure of the Msimba seed farm was to produce suring the main rains (February through May). This was inappropriate for Kito for a number of reasons:

1. Yields are substantially lower during that period (due to maize streak virus).

2. The seed cannot be ready for distribution to farmers for the following short rains.

The appropriate planting time for Kito would be in the short rains. Here, however, a different problem surfaces since the seed farm has insufficient drying facilities to deal with a crop coming off just before that main rains begin. A second problem with Kito is that the producer is not compensated for the lower yields with a higher unit price. To date, these problems have not been overcome and the supply of seed does not meet the demand. The FSR teams remain actively involved in the attempt to spread Kito more widely.

In general, our observation is that the community researchers live in a secluded sphere far removed from everyday issues. FSR teams, in contrast, come face to face with whatever problems farmers confront. Often in Tanzania this implies becoming involved in local and national policy issues. In Tanzania one issue which we have become involved with has been the prohibition (enforced at the local level) against inter or relay cropping any other crop with cotton. In Kilosa District this policy requires farmers to prepare new land in January at a time when the weeds are already quite high and the farmers are preoccupied with other crops. The on- and off-station experiments conducted by the FSR teams appear likely to demonstrate the advantages of relaxing this regulation and will thus provide a good example of the value of the FSR approach in other than technical spheres.

SUMMARY

Over the past three years, the TARO FSR section has achieved some success in introducing new methods of conducting agriculture research. We are pleased that the commodity researchers have reacted favorable but recognize that researcher have not grasped the advantages of conducting experiments with farmers and in seeing the technology development and dissemination process through to its conclusion.

We would suggest that anyone introducing a FSR program proceed in the same cautious and slow manner which we have in order to minimize misunderstandings and jealousy. The two research approaches really can compliment each other if adequate care is taken to ensure good communication.

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FINAL CONFERENCE QUESTIONNAIRE*

This questionnaire seeks to establish the current attitude of commodity researchers toward the FSR approach and the work carried out by the TARO FSR section.

I. AWARENESS OF THE APPROACH

1. Using a 1 (low) to 5 (high) scale indicate your level of awareness and understanding of the FSR approach:

   1.6 At the beginning of the Project (3 years ago)
   4.0 Now

2. Which activities, if any, contributed most to your change in awareness and understanding (rank in order)?

   1 (tie) Informal discussions
   1 (tie) Seminars
   3 Joint Fieldwork
   4 Books and Articles

II. GERNERAL ATTITUDE TOWARDS THE FSR APPROACH

3. Would you say that you are more or less favorably disposed to this research approach that you were three years ago?

   More Favorable – 92% Same – 8%

4. Would you describe yourself as:

   58% an FSR enthusiast
   42% mildly supportive of the approach
   ___ neutral
   ___ worried that it is not effective
   ___ Convinced it is a waste of time and resources

5. Which aspects of the methodology do you particularly like or dislike (be as specific as possible)?

   Most comments were favorable. The positive aspects cited were system diagnosis and client orientation (no one mentioned exper. procedures). Negative aspects of FSR included poor exper. methods overly critical of commodity research, and piecemeal approach.

III. OPINIONS ABOUT THE TARO FSR SECTION

6. In relation to the current status of the FSR section within TARO do you think that (choose one response for each part):

   A.) 75% more funding should be devoted to FSR
   17% less funding should be devoted to FSR
   ___ the current allocation of funds is appropriate
   8% Blank

*Answers were provided by 12 TARO commodity researchers during the USAID/TARO Final FSR Project Conference, June 27, 1986.

B.) 92% more personnel should be shifted to FSR

If yes, they should come from:
58% new recruits
34% transfers from existing programs.

___ fewer personnel should be in FSR
___ the current personnel allocation is appropriate
8% Blank

7. Do you think that the current arrangement of having separate FSR teams results in duplication of effort (if yes indicate which areas)

Yes – 42% No - 55%

The main area of duplication was seen as the FSR work on the research station.

8. Should the FSR teams continue to run their own on-station trials (why or why not)?

Yes – 55% No – 42% ? – 8%

Those in favor saw the FSR Team generating results to compare with one-farm work or working in areas untouched by commodity research

9. Should the commodity programs continue to run their own on-farm trials?

Yes – 42% No – 55% ? – 8%

IV. IMPACT OF THE FSR SECTION

10. Has the existence of an FSR team at your station had any direct impact on your own work? (be as specific as possible)

Yes – 50% - Most cited problem identification & bring farmer conditions and reaction to their attention.

No - 33%

? - 17%

11. What improvements if any should be made in the manner in which FSR currently functions within TARO

Most comments focused on improved interaction with commodity researchers. Many brought up the need for more manpower and funds.

12. What do you predict will be the status of the FSR section in five years time?

Very bright – 33%

Don’t know - 33%

Dependent on funding and institutionalization – 33%

13. Would you personally agree to be transferred to work full time on an FSR team (explain you reasons).

Yes – 8% No – 92%

Those who answered ‘No’ focused fires on their feeling that their expertise would be better used in the commodity programs. Secondly, they were uncomfortable with shifting to FSR from a personal standpoint because of its uncertain future.

COMMODITY RESEARCH TEAM/ADAPTIVE RESEARCH TEAM LINKAGES: A ZAMBIAN EXAMPLE

V.J. Eylands, R.E. Hudgens, S.A. Kean, and C. Kefi

Introduction

A Farming Systems Research and Extension (FSR/E) component vas incorporated into the research branch of the Ministry of Agriculture and Water Development (MAVD) in Zambia in 1980. In an earlier paper, Kean and Chibase (1962) reviewed the need for FSR/E in Zambia and the overall process of institutionalizing FSR/E into the fabric of an existing research effort on a national level. This paper seeks to document more fully the operational linkages established between commodity research teams based at the Mt. Makulu Central Research Station and FSR/E teams forking at the provincial level.

Institutional Framework

As is the case with other countries in the region such as Botswana (Baker and Hobbs, 1986), research and extension in Zambia are administered as separate divisions of the same government ministry. The FSR/E teams, which in Zambia go by the name of Adaptive Research Planning Teams (ARPI), and the Commodity Research Teams (CRT) combine to form the research branch of MAVD. However, ARPT also works in close collaboration with regional personnel from the extension branch of MAVD. The research-extension linkage at the provincial level has been further strengthened by the addition of a Research Extension Liaison Officer (RELO) to each multidisciplinary ARPT. The activities of the RELO, such as training sessions, field days, and newsletters, serve to keep both the CRTs and extension personnel in frequent contact with ARPT.

Formulating Linkages

The CRT/ARPI relationship plays a pivotal role in the "upstream" (CRT) and "downstream" (ARPT) two-way flow of information in the generation of relevant production technology for semi-commercial farmers. This necessitates open and frequent communication between members of the two groups. CRT/ARPT dialogue provides the basis for a better understanding of the role of each commodity within specific farming systems and helps identify constraints related to the production of each commodity. ARPT feedback on problems requiring technical component research, derived from close contact with farmers and extension personnel, aids CRTs in planning research objectives for specific target groups within the national agricultural section. In turn, ARPTs conduct multi-location testing of technical alternatives designed by CRT's under farmer's conditions in distinct agro-ecological regions of the country ARPT, therefore, complements, rather than distracts from, commodity oriented research.

During ARPT's Hedging stage, the CRT/ARPI linkage vas based primarily on the motivation and cooperation of individual scientists The flow of information between CRTs and ARPTs vas often hindered by animosity and the misunderstanding of individual roles in the collective research effort. The absence of CRT support in certain areas, such as animal powered tillage equipment, limited initial ARPT progress (Hudgens, 1986). Recently, however, detailed guidelines (Kean. 1985) have been established to formalize and structure the CRT/ARPT interaction. These mechanisms include.

1. Involvement of CRT scientists in ARPI surveys

In order to benefit from specialist knowledge on particular crops, CRT scientists are invited to participate whenever possible in the exploratory and follow-up surveys. The involvement may be indirect, such as in helping to develop a questionnaire to further facilitate the understanding of current farm practices, or direct involvement where CRT members actually accompanies the ARPI to on-farm interviews to obtain a better perspective of a particular crop in the farming system. Such cooperation also enables ARPI to understand those areas where technological solutions may already exist from analogous situations in other countries and could be tested with confidence in on-farm experiments.

2. Agronomic data sheets

In order to enhance the data base generated by CRT research over the years, agronomic data sheets are prepared after each ARPI survey has been completed. These sheets simply present quantified data, without interpretation, on the agronomic practices and technical problems encountered (e.g. an estimate of streak virus incidence in maize stands or the percentage of farmers who reported using retained hybrid maize seed). This does not entail conducting new surveys. Rather it simply insures the transfer of information to CRTs that might otherwise have gone unnoticed.

3. Annual meetings between all ARPT and CRT personnel

Approximately a month before the Annual Research Committee Meetings, which are held to review the previous season's results and discuss research plans for the upcoming season, a series of small group meetings are held between CRTs and ARPTs. In these Pre-Research Committee Meetings, on-farm constraints identified by ARPT in the different domains are presented in a standardized format (Appendix A) and proposals for the next cycle of both CRT and ARPI experimentation are discussed. Modifications or additional treatments to long-term CRT experiments are suggested. At the same time, new CRT technologies that have been shown to be feasible under researcher-managed, on-station experiments are turned over to ARPI for on-farm testing.

At the Research Committee Meetings, which is a larger annual forum that includes representatives of the government planning division, the extension branch of MAVD, other government ministries, and national universities, the CRT and ARPT members once again have a chance to interact, well in advance of the commencement of the rainy season. ARPT members attend the sessions held by specific commodity groups, and CRT members attend a general session held to summarize ARPT activities nationally. Although most CRT and ARPT research plans for the next season have been drawn up by this time, some refinements may still be discussed.

4. Site visitations and field days

Representatives of each CRT are expected to visit each provincial ARPT at least once during the cropping season to inspect the ARPT on-farm trials involving their commodity CRT presence is also encouraged during field day tours organized by ARPT for extension personnel and farmers. The ARPT National Coordinator in Lusaka arranges the visitation schedule. Invitations to specific training programs are issued to certain CRTs by the sponsoring ARPT. Conversely, CRTs are expected to invite members of the nearest ARPT to attend CRT field days on research stations and to show ARPI members around when they are visiting a research station. Otherwise, many CRI

members would have very little contact with farmers and many ARPT members would not have had the opportunity to observe on-station trials that may generate genotypes, which will be passed onto ARPT for on-farm testing in subsequent seasons.

5. Changing technical recommendations and extension messages

When a new recommendation is proposed, interested CRT and ARPT members are called together to discuss the implications involved. The most recent example of such a proposal occurred when one ARPT wanted to narrow a broad general recommendation down to something more geographically specific. At this point CRT members routinely evaluate the quality of the ARPT data in question. If the ARPT trials have been planned in unison with CRTs, the objectives of the trials are clear to everyone and approval is easily attained. However, prior to the implementation of guidelines for formal CRT/ARPT interaction, CRTs were often not previously consulted, and therefore these meetings commonly resulted in conflict and disagreement.

6. Newsletters and data exchange

Some CRTs and ARPTs publish newsletters. These are circulated widely within the research branch. Often the information of interest to ARPT members is hard to synthesize from CRT annual reports. Consequently, an effort is underway to insure that information on varietal screening trials, new varietal releases, and agronomic experiments is condensed and distributed to ARPTs prior to the Pre-Research Committee Meetings.

7. Crop research strategies

When a sufficient number of farming systems throughout the country have been surveyed during the expansion of ARPT studies, a crop research strategy will be drawn up using quantified data collected from across the country. In this way, ARPT will have an input into the work plans of each CRT both from the standpoint of breeding criteria for varietal improvement and from the standpoint of crop husbandry practices that are feasible given the labor and capital resource limitations of traditional and semi-commercial farmers. To facilitate the recognition of areas of potential improvement of each crop in the farming systems, CRTs are being asked to develop "crop profiles" (Appendix B), showing the ecological adaptability and management requirements of promising and existing varieties.

Weakness in the CRT/ARPT Linkage

At present in Zambia some of the provincial ARPTs and CRTs are interacting in the prescribed fashion, but there are many deviations from the norm. The great distance between the ARPT and the CRT members hamper site visitation. Communications by telephone or post are difficult at best and often untrustworthy. A high rate of staff turnover on both teams inhibit long-term relationships from developing. In many instances, scientists from certain ARPTs or certain CRTs are strongly influenced by the policies and project objectives of specific donor agencies. However, perhaps the greatest existing inhibition is the lack of understanding and confidence in the FSR/E philosophy. A personal survey of CRT scientists in Zambia revealed that many did not fully believe in what ARPT was doing and could not see how ARPT could help them achieve their CRT's objectives. Most CRT scientists have had very limited exposure to ARPT philosophy. On the other hand, some ARPT members are equally

hesitant to interact with CRTs. When lines of communication between CRTs and ARPTs are not open or are not utilized, members of each component tend to design experiments according to constraints as they see them. Disagreement over priorities, much duplication of effort, and a general parting of ways results. Neither side can appreciate the work of the other, and the government resources are dissipated over an incongruous conglomeration of research activities.

Most CRT programs in Zambia are heavily biased towards plant breeding. During the early years of FSR/E implementation, there vas a distinct division of work by academic discipline with most of the agronomic work done by ARPT agronomists, often in isolation from CRTs Many of the promising technologies were hastily taken from research-managed to farmer managed testing in an attempt to step smartly through the methodological stages of FSR/E theory. As these promising technological innovations lost their glitter in the harsh realities of farmers' fields, there vas an occasional loss of respect for ARPT among farmers. With the addition of agronomists to CRTs, hopefully this disciplinary barrier will be a thing of the past.

Cooperative CRT/ARPT experiments

Although it is not clearly specified in the preceding list of obligatory CRT/ARPT interactions, many CRTs work closely with certain ARPTs on specific experiments of mutual interest. A collaborative study involving two provincial ARPTs and the Sunflower CRT to evaluate sunflower varieties using different planting methods over a range of agro-ecological conditions will illustrate this point. The data presented comes from a geographical area with plateau characteristics with an average elevation of 1,000 meters above sea level and a rainfall period from November to April. Although total precipitation is variable within and between seasons, in general it averages 800 to 1,000 mm . Most of the area under cultivation has a uniform topography with sandy (Sandveldt) soils and isolated pockets of heavier textured (Red Clay) soils.

The initial ARPT diagnostic surveys of small farms in the Central Province revealed that most of the sunflower acreage in that province vas broadcast seeded and that new varieties released by the Sunflower CRT were not being utilized. At the pre-research committee meetings held a few months before the beginning of the rainy season, the Central Province ARPT and the sunflower CRT scientists discussed the implications of these practices and expressed their desire to design an experiment to compare the farmer practices against current recommendations for both row planting and new varieties. ARPT exploratory trials and CRT on-station trials had shown that row planting resulted in higher yields than broadcasting the seed, but little attention had been given to economic returns to labor invested. Also the yield differences noted between local and new varieties were questionable due to the vide variation in local germ plasm. In fact, what vas frequently considered to be local seed vas in most cases merely saved seed from formerly released open-pollinated varieties.

The never varieties had higher oil contents, better disease resistance, and more agronomic uniformity than the local grown materials. During previous ARPT on-farm trials, farmers had expressed a preference for the shorter stature and earlier maturity of the new varieties Results from these experiments suggested that sunflower productivity could be improved through the use of varieties with higher yield potential and higher oil content. However potential bird damage, adaptability to conditions of low soil fertility, and tolerance of weed competition were major concerns. It was, therefore, necessary to test the new varieties against locally adapted germ plasm under on-farm conditions.

The CRI/ARPT pre-research meetings also revealed that row planting prevailed on sunflower fields in the Southern, Eastern, and Lusaka Provinces. Consequently, a two-year factorial experiment involving three sunflower varieties and two planting methods vas devised. The factorial experimental design chosen for this experiment enabled detection of all possible interactions, including the two-way interactions of variety by planting method, variety by location, variety by planting period (mid-December or mid January), and variety by season interactions.

At the Annual Research Committee Meetings a few weeks later, the experiment vas again discussed and several modifications proposed. Since a modified stability analysis (Hildebrand, 1984) of the results vas desired, it vas decided that the planting dates should correspond to both mid-December (recommended) and mid-January (farmer practice) planting periods. Also, several CRT-managed research station sites in the area should be utilized to provide a more favorable production environment to strengthen the environmental index range. The experiment vas planted at 45 sites during the 1984/83 cropping season and on 40 sites the following year.

In spite of some problems in regard to bird damage, stand establishment, and weeding management, the seed yields of improved varieties using recommended planting methods were found to be progressively higher than the yields of local germ plasm using local husbandry practices as the production environments became more conducive to plant growth and development (Figure 1). The economic analysis of these results allowed refinements in Recommendation Domains for sunflower technology over a large section of the country. However, the benefits of this study were equally important from the standpoint of facilitating mutually beneficial CRI/ARPT operational linkages, which took the form of planning sessions, frequent discussions, the exchange of information, and CRT site visitations. CRT participation in ARPT field days and extension training programs further enhanced the linkage. In the course of this collaborative study, CRT scientists were exposed to on-farm conditions and the farming systems perspective. Conversely, CRT scientists were able to suggest means by which ARPT could effectively lover the coefficients of variation in on-farm experimentation.

Conclusions

A concentrated effort on the part of the ARPT National Coordinator to formalize CRT/ARPT interaction has helped to overcome a major obstacle to the institutionalization of FSR/E. ARPT is slowly gaining recognition and acceptance within the established CRT network. To remain viable, the CRI/ARPT linkage will require the support and active participation of all agricultural scientists in Zambia The mutual understanding of the role of CRTs and ARPIs in the overall research thrust is fundamental to a successful CRT/ARPT linkage. Detailed guidelines serve to clarify misunderstandings and provide incoming scientists with a clearly defined format of operation. In this sense, the Zambian experience may serve as a model for the implementation of FSR/E elsewhere in world.

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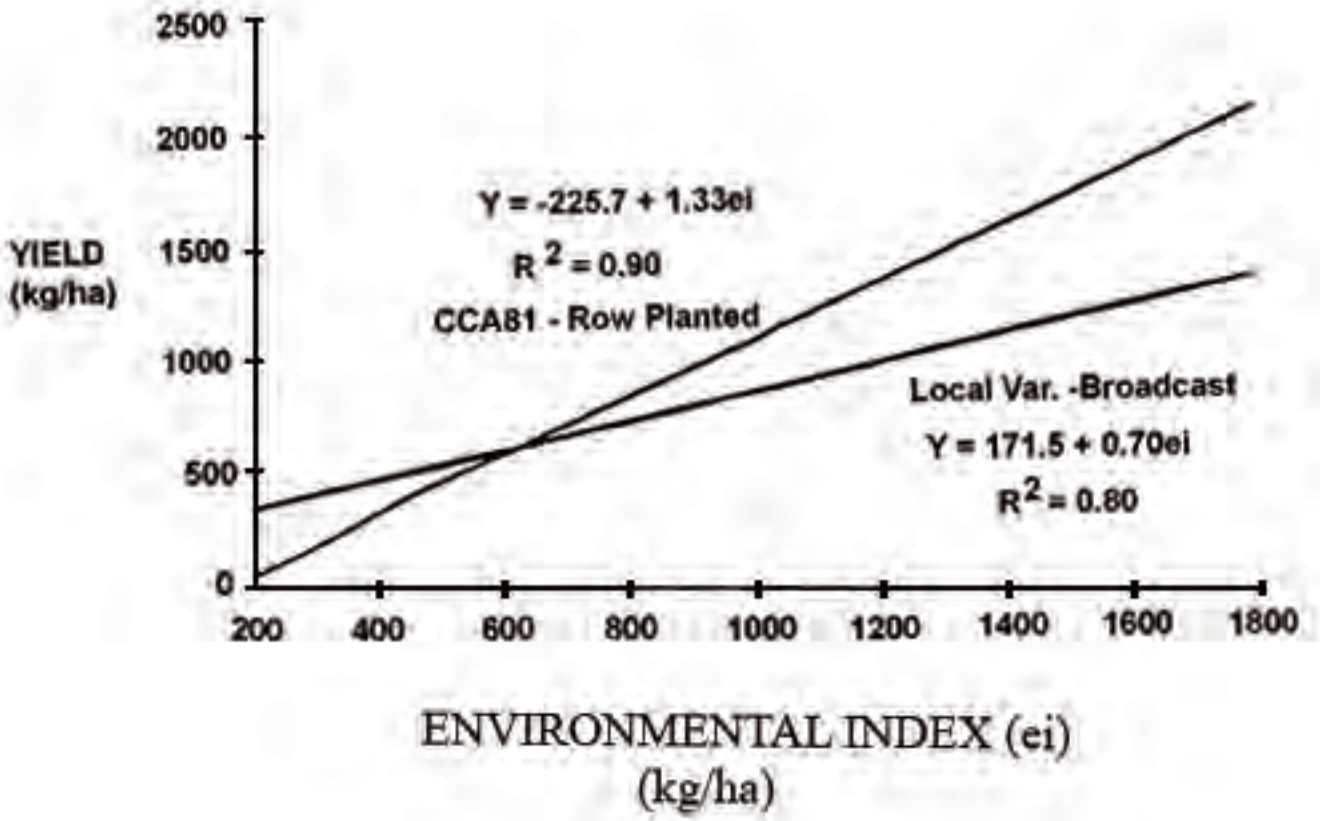
Figure 1. Comperison of the yield stability of two sunflower varieties in different planting systems in the Central and Lusaka Provinces of Zambia (1985/86 season).



APPENDIX A

FORMAT FOR USE WHEN PRESENTING IDENTIFIED PROBLEMS TO COMMODITY AND SPECIALIST RESEARCH TEAMS IN RESEARCH COMMITTEE MEETINGS

1. Commodity or specialist team to be involved.

2. Province.

3. Location of the farming system ($).

4. Crop (importance in the farming system).

5. Technical description of the problem.

6. Description of the problem in terms of the system.

7. Benefits of successful research (Number of farmers who could benefit; importance of the crop to these farmers; market potential; increased output anticipated if the solution is successful.

8. Research program required (long-term and short-term).

9. Key constraints within which a solution would have to work.

APPENDIX B

CROP PROFILE FORMAT

1. Name: Common name, generic name, and any known Zambian names.

2. Soils

   a. Acidity: The pH range for optimum growth should be indicated and a indication given of the way in which yields decline at pH levels below this. Often the yield potential at sub-optimal pH is very important for farmers who can afford to apply lime.

   b. Texture: Indicate preference for clay or sandy soils.

   c. Structure: How prone is the crop to drought, water logging, compacted soil, etc.?

   d. Depth: Does it require a deep soil, or can it perform well on relatively shallow ones?

   e. Nutrients: Response to macro-nutrients (give some idea of actual response rather than an economically or biologically optimal level).

   f. Any other important requirements of the soil environment.

3. Temperature

   a. Maximum and minimum air temperatures. If the sensitivity varies with growth stage, indicate this. Give optimum temperatures.

   b. Sensitivity to soil temperatures at different stages.

   c. Any other aspect of temperature directly or indirectly affecting the crop.

4. Rainfall

   a. Duration of moisture required.

   b. Mean monthly requirement, and most sensitive stages.

5. Altitude limitations.

6. Day length sensitivity.

7. Botany

   a. What is the range of plant form? Stress particularly those features of agronomic importance (e.g. weed suppression, need for support).

   b. Nodulation: What conditions are conducive to natural nodulation? (Where appropriate).

   c. Any other botanical features considered to be important.

8. Management

a. Planting date: This should be related to rainfall, or other environmental features.

b. Seedbed preparation: How critical is this operation?

c. Depth of planting.

d. Plant population and plant response to changing population.

e. Time and method of fertilizer applications.

f. Days to harvest.

g. Ability to intercrop.

h. Crop/weed competition and critical weed periods.

i. Pest and disease problems, potential for resistance. Relate attack to environmental factors.

j. Storage problems.

k. Any other important management aspects (e.g. irrigation for vegetables).

STRENGTHENING RESEARCH-EXTENSION AND FARMER COMMUNICATION LINKAGES IN KORDOFARN PROVINCE, SUDAN*

INTRODUCTION

In the spring of 1985, the writer examined communications linkages between Extension and Research in the Kordofan Region of Sudan. The Western Sudan Agricultural Research Project was financed by USAID and the World Bank (WSARP). Professionals from the Agricultural Research Corporation (ARC) and Washington State University (WSU) administered the project.

The project approach was in the Farming System Research mode. The study was aimed, in part, at assessing the status of research-extension communication linkages. The term "Extension" reflects a broader connotation than just the organization. In this paper, Extension denotes all agencies, organizations, and associations in both public and private sector that promote the diffusion of technologies.

Western Sudan, including the Kordofan Region, must depend to a large extent upon small farmers for increases in agricultural production to meet the nutritional requirements of a tenaciously increasing population. Scientists, who in the past have often found it easy and convenient to ignore the small farmers, are now becoming more aware of the small farmers' role in the development process. This is due to the large number of small farmers in the Kordofan Region (500,000 farm estimate) and to the impact of the small farmers' problems on the rest of Sudanese society (Sabah, A., 1985). There is a growing recognition among development experts for greater concerns for equity. This means a more equal sharing of the amenities of life must be considered as part of the goals of a policy of development for the Kordofan Region. This has been clearly recognized with the development of the Western Sudan Agriculture Research Project (WSARP). A key to success is the active participation by small farmers in the development effort. This is being achieved through the Farming Systems Research (FSR) model implemented by Sudanese and Washington State University Researchers.

There are constraints that need to be overcome by small farmers in order for them to be viable. These generally revolve around variables associated with technological changes, institutional arrangements, and information needs. Three major types of farmers were identified as target audiences or groups for the project. These are sedentary, transhumant and nomads. A major purpose of this paper was to help put into perspective the roles of information, communication, and institutional activities in removing constraints which block the acceptance of FSR-generated technology. Some questions on the institutional linkages concerning the flow of information is reviewed. A number of strategies to improve research-extension communications linkages are proposed.

Many past efforts to reach the small Sudanese farmer with development projects have been failures. The lack of institutional infrastructure and institutional services for small farmers has been a major constraint contributing to those failures (Sabah, A., 1985).

For the purpose of this paper "institutions," broadly defined, refer to the patterns of relations among people, including relations among organizations of people. The concept of institution includes customary ways of doing things, as well as reference to specific organizations.

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By definition, institutions are products of relatively stable and routine patterns of interpersonal and inter-organizational behavior (Shaner, B. et. al., 1983). Institutions are thus limited in their flexibility and capacity to innovate. This characteristic of institutions is both a strength and a constraint.

Institutional services encompasses the people problems associated with the task of overcoming the gap in food demand and supply. It is the people who eat, people who reproduce people, people who produce food, people who become organized into formal and informal groups. It is these people who discover new knowledge, and people who accept or reject the knowledge available to close the food-population gap. Institutions and institutional practices inadequate to the task can be enormous barriers in restricting the flow of agricultural information needed to increase production.

Part of the solution is improving the information flow between institutions and more firmly establishing linkages between the developers, the deliverers, and the users of information. An interrelated system between research and extension is required in order to improve these information linkages. At least five functions must be fulfilled before any real improvement can take place: 1) research and development of appropriate new technology; 2) adequate local testing of technological developments; 3) dissemination of information to users; 4) adoption of new practices; and 5) a continuous system of feedback and interaction among all participants in the system with emphasis on the involvement of the farmer (York, E., 1981).

The WSARP has primarily addressed points one and two during the first stages of the project. Project scientists have emphasized a problem solving type of research that is concerned with the adoption of improved varieties and cultural practices. This is a research activity where multi-disciplinary teams have pursued selective interventions of specific crops.

The major emphasis has been on-farm and in-herd/flock trials. In this role, project scientists have worked directly with farmers and have in effect taken on major extension responsibilities. This has, no doubt, been an essential first step in the FSR/E process. However, extension and other developmental agencies must become increasingly involved in the FSR/E process in order to expand the delivery of validated agricultural information to a greater number of farmers. The challenge is great. Norman Borlaug, for example, estimated that new agricultural technology has reached only 10 to 15 percent of the world's three billion farmers (Borlaug, M., 1969). At best only a limited number of 500,000 farmers in Kordofan Region have been impacted by new agricultural technology. It is, however, apparent that all appropriate institutions must be involved and supported in the effort.

SETTING

Institutional linkages — WSARP — Internal

The writer first looked at linkages within WSARP and in relation to ARC (Agricultural Research Corporation). Dr. El Hag, head of the El Obeid Research Station, described the formal planning process within WSARP. Through this process, individual scientists take the leadership to develop specific research projects within the approved overall project research strategy. Research reports and priority needs within a given station or area provide needed background information to assist in project development.

Researchers located at the stations form station research committees that address issues relevant to the activities of that station. This may mean involvement in more than one production system, depending upon the location and the activities. From the individual research station committees various administrative matters, including planning, budget, etc., go to a system/program committee, of which there is one project-wide for each of the systems. The plans envisioned at least three systems under investigation at the outset. These include the transhumant system, the nomadic system, and the sedentary system.

After consideration in the system/program committees, recommendations and information proceeds to the project research committee, which is the central research committee for the project. Information then flows from this research committee of which the Project Director is Chair to the WSARP Advisory Committee, which is chaired by the Director General of the ARC. Information and recommendation from the WSARP Advisory Committee then goes to the Project Director. The Director is in turn responsible to and conveys the information to the Director General of the ARC. Thus, the research administrative structure flows from the researchers ultimately to the Director General of the ARC.

The World Bank and AID documents indicated the establishment of a Project Advisory Committee. This committee is composed of representatives and scientists from various organizations within Sudan as well as from international centers. The committee is advisory in function and is chaired by the Director General of the ARC. It examines proposed activities by the Project Research Committee as well as having the prerogative of initiating input and recommendations to the Project Director.

These are formal, in-house procedures for planning, implementing, communicating, evaluating, and reporting research work with the WSARP framework. The channels are quite formalized, relying on personal interaction between scientists, written reports, conferences, seminars, and formal critiques of proposed projects and research results.

WSARP Linkages with Farmers

FRS researchers have utilized on-farm trials as their major research approach with some emphasis of livestock trials in Kadugli. This approach was utilized not only to test but to validate agricultural technology. Researchers soon find themselves fulfilling a traditional Extension role

in working directly with the farmer, They are, in effect, the representatives of a governmental agency. This is a formal institutional channel. Within this framework, researchers interact with farmers, village leaders, merchants, village council members, and others.

WSARP in the Kadugli area has carried out an Extension role for several years in terms of village surveys, contacts with farmers and distribution of selected inputs (Reaves, E., et. al., 1981). Extension has been somewhat active in the distribution of certain inputs in the El Obeid area. However, the Coughenour study (Coughenour, 1985) indicated that few, if any, respondents could remember or identify agricultural extension representatives in relation to innovations and change. The same study also indicated that Dr. Tareke Berhe (INTSORMIL) who had worked for three years in villages near El Obeid was known by name by less than ten percent of the respondents.

Researchers conducting on-farm trials may be faced with an 'identity crisis" in relating to farmers. Villagers (Coughenour, 19&5) tended to be distrustful of many government representatives who they feel "want" something from them rather than visualizing any positive help, it is clear that researchers must try and clearly communicate who they are, who they represent, and the purpose of their visitations to farmer (Coughenour, 1985). This necessitates a great deal of reinforcement. Researchers conducting on-farm trials indicated that they employed a variety of methods in working with farmers. These included: result demonstrations (on-farm trials), method demonstrations, face-to-face visits with farmers and groups, meetings with farmers and farmer groups, informal tours of farmers' fields, and utilize simple pictures to illustrate points. The basic approach was the "show and tell" method with the farmers demonstrating what they had learned.

WSARP Scientist Linkages with Agricultural Development Agencies in Kordofan

The development process in Kordofan Region involves domestic government institutions from the highest levels of government to the lowest and the activities of foreign development agencies. An understanding of these institutions and how they relate to one another is a prerequisite to effective participation in development activities. Actions taken by developmental agencies are highly dependent for initiation, implementation and evaluation on the quality, quantity, and utilization of information flow.

The upper level of Sudan's government bureaucracies tends to operate in ways similar to their counterparts in developed countries. However, at the lower or provincial or district level of government, cultural differences intrude more strongly on institutional forms and information flows. The organizations and operations of lower level institutions concerned with agricultural development are of prime importance in facilitating information flow and project implementation.

Communication linkages between research and agricultural development agencies including Extension assists in identifying some of the barriers in technology flow. The communication of a new technology or innovation to farmers and its evaluation and its acceptance by them is the final step in

the process of technology adoption. All formal institutions in Kordofan Region depend in varying degree on local, informal networks of communication to spread new ideas. Formal and informal systems must be effectively linked and mutually supportive. Then the transfer of technology from research and development centers to farmers occurs rapidly and with a minimum of disruption for farmers to increase production efficiency. The informal system spreads information about the innovations. Then the feedback information on their local applicability and on other needs of farmers stimulates further research and development. Most formal and informal systems of technology development operate this way.

In efficiently functioning systems, however, the. formal and informal systems mesh in such a way that blockages, distortion, and loss of information are minimized. It's interpretation, evaluation, and utilization are enhanced at the same time. In traditional agriculture, by definition, formal institutions of technology development and its transfer to farmers do not exist or are ineffective. Innovative change occurs mainly by borrowing ideas and practices from other cultures. Change is slow and erratic. This has characterized agriculture in much of Kordofan until recently (Michael, B., 1984).

The components of a formal system of technology development have been established by the ARC, WSARP, INTSORMIL, and the Kordofan Regional Ministry of Agriculture. Other development agencies are also present. As new seeds, cultural practices, and other innovations become increasingly available, the need to develop effective linkages with village networks of communications becomes more urgent.

Several major questions were the focus of this section. One of the questions was to identify and evaluate the linkages which ARC has with the Extension Service and other modes it used to disseminate its findings and recommendations. A complementary question was to investigate linkages between the WSARP research program, Regional Extension programs and other information dissemination mechanisms in Western Sudan.

There are a number of both national and international agencies involved in the agricultural development of the Kordofan Region. Agricultural Extension in Kordofan is charged with the primary responsibility for diffusing new technology to the farmers. There are also extension components to such units as Veterinary Services, Horticulture, and Forestry. Individual extension-type efforts from the Plant Protection, Soil Survey, Range Management, and Cum Arabic units were reported by MOA officials.

INTSORMIL (International Sorghum and Millet Program) as an international organization involved in millet and sorghum improvement has an impressive record in the El Obeid. It is now preparing to address Kadugli in terms of developing new varieties and cultural practices. This effort has been closely coordinated with the research work of the ARC and WSARP. The major emphasis has been working directly with the farmer in on-farm trials with selective livestock introduction in the Kadugli area.

There are other organizations, both national and international, working in the Kordofan Region in agricultural development. Some of these

organizations have major extension-type efforts. In the Kadugli area, for example, both the Nuba Mountain Agricultural Development Corporation and the Nuba Mountain Rural Development Program have extension-type units which provide advisory services to farmers. In fact, many of the Kadugli Extension staff are working with agencies in a variety of projects (Gassim, A., 1985).

The Nuba Mountain Agricultural Corporation is carrying out an agricultural research and development program with some 500 farmers. UNDP is engaged in range management, desertification prevention, and garden programs. UNICEF has drilled over 1,000 wells in the rural areas of the Kadugli District alone, as well as in many other areas of the Kordofan Region. As water becomes an increasingly important constraint for both domestic and livestock use, this impacts on agricultural development programs. CARE has been involved in several garden-type projects.

METHODS

A survey of the inter-organizational communication patterns between WSARP researchers and representatives of agricultural units in the Kadugli and El Obeid area was conducted (See Table 1). The survey was to establish a general type of pattern of the number of contacts researchers had with different representatives of agricultural units in their area.

A total of 18 researchers — 9 at Kadugli Station and 9 at El Obeid were interviewed. Each researcher was asked to estimate the number of contacts made with representatives of the different agricultural institutions during the past program (1984-85) year. These contacts could be either researcher or agricultural agency representative initiated. The purpose of the survey was to estimate the number of contacts made between researchers and other development units. Multiple estimates by researchers were frequently made. Responses from interviewees was cross checked with their monthly and annual reports. Several examples illustrate this point. Millet and sorghum researchers reported more multiple contacts with representatives from INTSORMIL and Plant Protection than with other agricultural units. Likewise, researchers working in livestock production more frequently made contacts with professionals from veterinary services in range management. A lack of time prevented interviewing extension personnel.

The writer utilized a communication patterns instrument developed in the Lesotho WSU/FSR Project (Trail, T., 1985). The instrument was pretested in Sudan with researchers and extension personnel.

Data were analyzed and presented to the respondents through follow-up interviews or small group seminars. The purpose of this process was to cross validate the credibility and trustworthiness of the data. Sixteen of the 18 researchers participated in this process. They strongly agreed that these data were an accurate reflection of inter-organizational communications patterns between WSARP researchers and representatives of other agricultural units. The researchers generally supported the recommendations of the study.

RESULTS AND RECOMMENDATIONS

In general there were many more reported contacts with agricultural extension (N-105). Many of these contacts involved extension personnel contacting researchers about new varieties and cultural practices. A higher degree of researcher-extension contact was reported in the Kadugli area. Five extension workers worked with the WSARP economist and sociologist for a seven week period in gathering data from farmers in conducting village socio-economic studies. In this case one contact per week per extension worker was utilized to come up with the general contact figure.

The estimated number of contacts provided only a generalized idea of the inter-organizational communication patterns between WSARP researchers and representatives of agricultural development units in the Region. Several qualitative questions concerning the substance of the contacts were asked. The majority of contacts fell into several categories. The contacts were in many cases subject matter specific, i.e. an extension agent asking a millet or sorghum breeder for the latest recommendations on varieties and cultural practices. A substantive number of contacts could be classified as problem solving requests. These were both researcher and agricultural representative oriented or initiated. For example, a researcher working with farmers in the Kadugli area was asked about information concerning the animal traction program. The researcher then contacted the Nuba Mountain Agricultural Corporation and communicated the relevant information back to the farmers.

Dr. El Hag, Director of the El Obeid station, reported that members of the various Regional MOA units were brought together to meet with station researchers. The tentative research plans for the year were reported by the researchers. MOA representatives were asked for input concerning their ideas and perceived needs of both farmers and their programs. This information was utilized in revising the research plans. This type of approach is recommended to strengthen linkages between researchers and representatives of other agricultural units. These types of meetings need to be formalized as part of the regular plan of work of the cooperating agencies. This process can help to organically link and formalize program and communication patterns between the various agencies. Through this process a series of institutional questions can be asked and addressed:

1. What are the major problems relative to the small farmer?

2. How are such problems identified?

3. What tools do the agencies have at their disposal for attacking these problems?

4. How do the agencies interact with government agencies in planning and conducting research?

5. What impediments to research are common and what means exist for resolving such problems?

Where resources are scarce and limited, the representatives of the various agencies should pool resources and work toward the solution of common problems affecting the farmer. The establishment of a formal Rural Development Committee at the district and regional level made up of the representatives of the various agriculturally related agencies was recommended, Representatives from Farmer Unions or village councils should be included. Care needs to be taken to include input from both traditional and farmers on mechanized schemes so that their interests are protected. Information from the informal communication system regarding the acceptability or perceived constraints of new innovations must be considered by such a formal group. Work in terms of formal and informal channels of information also needs to be carefully studied by such a group (Coughenour, 1985). Information concerning the needs of the small farmer can also be provided by researchers and others working with farmers through the FSR/E process.

Researchers were also asked to indicate the types of contacts of situations in which they communicated with representatives of agricultural agencies in Kordofan Region (See Table 2). There were 9 researchers in Kadugli and 9 researchers in El Obeid who were interviewed. Researchers were asked to indicate if the contacts were: individual or personal contacts, group meetings, field days, field trips, correspondence, an exchange of materials, and/or other means.

Individual contacts whether made during official business hours or on a casual basis were defined as formal contacts in case official business was discussed. Group meetings were joint sessions such as planning meetings with representatives from two or more institutions. Seminars and workshops were classified as group meetings. Field days were defined as officially organized events such as a field day on a station farm. Field trips were events where a researcher and a representative from another organization would go out to the field to jointly visit on-farm trials. Correspondence referred to official letters or communiqués from one representative to another. An exchange of materials was considered the sharing of written materials, plant materials, etc. from one individual to another. Radio, television, newspapers, and journals were mentioned by the writer in the other category. However, there were no responses to this category.

The frequency or use of a particular contact or contact situation was not asked by the writer. Researchers were asked if they utilized a particular type of contact with representatives from a specific institution. If the response was, "I use the individual contact method with Extension agents," then only the figure I went into the individual contact column. Multiple individual contacts for one researcher, for example, were not tabulated. However, several subjective questions helped identify some degree of contact frequency. There was no differentiation between contacts initiated by researchers or other agricultural representatives.

Not surprisingly, individual contacts represented the major means for communicating between researchers and representatives of other agricultural agencies. Again, contacts appeared to be heavily weighted toward subject matter related questions or problem solving situations where a professional needed assistance. Individual contacts were made more frequently with Agricultural Extension and INTSORMIL representatives. Researchers most

frequently mentioned contacts involved work involving on-farm trials and specific requests for crop production recommendations. Many researchers indicated that individual contacts with extension personnel and INTSORMIL scientists could range as high as 25-50 contacts per year. Individual contacts were by far the most important type of contact utilized.

Secondly, in terms of use, are group meetings. Meetings were defined as joint planning sessions, workshops, seminars, or casual meetings between professionals where business matters were discussed. A number of meetings between WSARP scientists and INTSORMIL researchers were reported. Sit WSARP scientists indicated that group contacts might range from 10-25 per year with their INTSORMIL colleagues. Group meetings were reported less frequently with representatives from other institutions. An example of a meeting with researchers and representatives of the MOA units in El Obeid was reported by Dr. Hag, Director of the El Obeid Station. At the meeting tentative research plans of the station were presented and input requested from the Director and researchers. Similar type meetings need to be planned and institutionalized. Researchers need to plan with other institutional representatives their involvement in the planning, designing, implementation, and evaluation of on-farm trials. Subject matter training should be carried out by researchers with other institutional representatives through seminars, workshops, and other types of training settings. These should be jointly planned.

Field days were not reported by any of the researchers as a type of contact. The reason that field days in 1984 were not utilized was that trials were not worth showing because of the abnormally dry season. Several field days were planned, but cancelled at the last minute. Field days can be powerful learning experiences, and should be utilized in the future.

Field trips to inspect on-farm trials were mentioned as types of contacts primarily with INTSORMIL scientists and Extension personnel. The number of such contacts or field trips ranged as high as 25 to 35 per year per scientist reporting the use of such a method. This is not unusual since applied research using on-farm trials is the heart of the research approach being utilized by the WSARP. It is recommended that other relevant agricultural representatives be invited to accompany WSARP researchers on field trips.

Correspondence is a means of communicating messages. Correspondence was mentioned as a means of contacting "officially" other agricultural representatives. Many researchers indicated that correspondence was most frequently a means utilized by station administrators. Personal contacts (formal and informal) were much more prevalent between agricultural professionals at district and regional levels. This appeared to reduce the extent of the need of written communications.

Researchers more frequently utilized the exchange of materials or information with other institutional representatives. The exchange of materials ranged from a report, to a technical bulletin, or to plant material. Each research station, for example, sends out a copy of their annual reports to USAID/Khartoum, ARC, Regional Ministry of Agriculture, El Obeid, Agronomy Department, University of Kartoum, University of Gezira, Wad

Medani, Ministry of Finance and Planning, El Obeid, ICRISAT, Sudan, UNICEF, El Obeid, CARE/Sudan, and copies to several other organizations. The Regional Ministry of Agriculture in El Obeid distributes these reports to all units within the region. Annual reports and publication of research results should be sent to all of these units. In addition, reports should be sent to the Agricultural Bank, Nuba Mountain Agricultural Development Corporation, Nuba Mountain Development Program, German Technical Assistance Program, and UNDP.

There was an addition of another category. However, no contacts such as radio, television, newspapers, and magazines were mentioned. Radio has limited possibilities. The one station in El Obeid has an effective broadcasting radius of only 10 kilometers. However, if the station increases its broadcast range then researchers and extension personnel could jointly prepare appropriate agricultural programs for farmers. Research in Kordofan indicates that there are from 10 to 15 radios per 100 households in most villages (10). So radio cannot be discounted as an effective means of diffusing agricultural information. Added support will be needed to develop an educational broadcasting facility to make this possibility come true. The Basic Village Education Project in Guatemala might offer some ideas for the use of radio (BVE, 1978).

Television is not a viable possibility at this time. There are very few sets and these are located in major towns. Newspapers come into El Obeid and Kadugli from Khartoum. The development of local newspapers with some agricultural information is always a possibility. However, the development of a local newspaper would need to come from private initiative.

ARC linkages with the Extension Service and other agricultural institutions in Kordofan Region has been reviewed. Modes utilized to disseminate findings and recommendations have been discussed. The major types of contacts were personal contacts, group meetings, and field trips. There appears to be an increasing emphasis for WSARP scientists to use more group meetings, on-farm trials, and field days. Establishment of formal and organic linkages between research and other extension oriented institutions is recommended.

A number of opportunities appear possible for communicating research information which has been validated through on-farm trials. This includes the establishment of more group aggressive leadership with such institutions as the Agricultural Bank, Farmers Union, Nuba Agricultural Development Corporation, and the Nuba Mountain Rural Development Program. The latter two groups have active extension type programs impacting on mechanized farm projects. On-farm trials, joint research efforts, and training of extension workers are but a few of the possibilities that could be achieved.

Contacts with merchants, periodic vendors, and mobile merchants identified in the Coughenour study (Coughenour 1985) as playing important roles in the diffusion of agricultural technology need to be considered (Coughenour, G., 1985). These individuals operate in the informal system, and yet have contacts in almost all villages in Kordofan. The initial source of many new varieties of seeds come through these individuals.

Developing simple pictorial fact sheets with information about validated varieties and cultural practices is a possibility. These could be utilized through a "bulletin" distribution system reaching into the majority of the Kordofan Region villages. This idea needs to be researched in greater detail. The high illiteracy rate of from 90 to 95% is a major constraint; however, there are some literate people in most villages who might be utilized as educational agents.

The establishment of educational exhibits or booths in key market places would allow the Extension Service to come in contact with many more people. This is based on the assumption that Extension could prepare educational materials based on validated research findings from WSARP to distribute at key markets using this booth approach. Coughenour (1985) indicates that most villagers will come to markets with some degree of frequency. Educational booths could be rotated from village to village and thus provide an effective cost-benefit ratio and means of reaching farmers. Again, the use of such methods is predicated on the fact that Extension will have useful agricultural information or materials to distribute. The development of these ideas will require careful research, pilot testing, and donor support.

The use of some of the informal systems such as kinship networks indicates some intriguing educational possibilities. These informal systems need to be further researched in order to determine the most effective way to utilize them in diffusing agricultural information. It is clear from the research on communication processes of Kordofan farmers that they are willing to change if innovation is clearly proven to be economical, reduces risk, and is available (Coughenour, C, 1985). Valid agricultural information coupled with imaginative and cost-benefit educational techniques could increase the effective flow of information that would benefit the majority of the producers in Kordofan.

A survey of the inter-organizational communication patterns between researchers and representatives of agricultural units in Kordofan Province was conducted. Evidence indicated that the majority of the contacts made between professionals was on an informal basis and generally limited. Formalized inter-organizational linkages need to be made to formalize program and communication patterns between the various agencies.

Little evidence was apparent in terms of utilizing merchants or vendors as potential sources of information for farmers. The experience for a number of other developing countries shows that there are a number of alternative and complementary approaches. These show some promise of promoting technology transfer in agriculture to increased use of private sector channels. These include the delivery of information of services concerning agricultural technologies and recommendations and concerning selective interventions to improve agricultural production. These experiences in other countries need to be studied to see if they can be adapted to fit into designing a more effective dissemination program for agricultural information in Kordofan Province.

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Table 1

INTER-ORGANIZATIONAL COMMUNICATION PATTERNS BETWEEN WSARP RESEARCHERS AND REPRESENTATIVES OF AGRICULTURAL AGENCIES IN THE KORDOFAN REGION

Institution	**Estimated No. Contacts During Past Year**
Regional MOAC	1
Agricultural Inspectorate	
Horticulture	23
Extension	105
Plant Protection	26
Soil Survey	7
Veterinary Services	13
Forestry	6
Range Management	9
Gum Arabic	1
INTSORMIL	45
Agricultural Bank	5
Nuba Mountain Agricultural Development Corporation	27
Nuba Mountain Rural Development	14
German Technical Assistance	7
UNDP	3
UNICEF	15
CARE	8

A total of 18 researchers were interviewed. Multiple estimated contacted for each researcher are reported.

Table 2
TYPES OF CONTACTS REPORTED BY RESEARCHES WITH REPRESENTATIVES OF AGRICULTURAL AGENCIES IN KORDOFAN REGION

Institution	Individual Contacts	Group Meetings	Field Days	Field Trips	Corres-pondence	Exchange of Materials
Regional or District MOAC						
Ag inspectorate	4	1			2	1
Horticulture	5	1			2	2
Extension	12	3		4	3	2
Plant Protection	3	2				1
Soil Survey	1	1				1
Vet Services	3	1			1	2
Forestry	2	1			2	2
Range Management						
Gum Arabic				7	3	6
INTSORMIL	9	6				
Agricultural Bank	1					1
Nuba Mountain Agricultural Development Corporation	4	1		1	1	3
Nuba Mountain Rural Development Program	2	1		1	2	2
German Technical Assistance	2					1
UNDP	1					
UNICEF	2					
CARE	3					

A PARTICIPATORY APPROACH IN DEVELOPING AN APPROPRIATE FARMIMG SYSTEM IN 8 IRRIGATED LOWLAND VILLAGES[1]

Jake Galvez Tan[2]

This paper summarizes the five and a half years work of the Agency for Community Educational Services Foundation[3] or ACES community organizers (COs) in eight (8) villages of Nueva Ecija in the Central Plains of Luzon, Philippines. In the course of organizing communities in the said areas[4], ACES found it necessary to adapt the principles of appropriate technology[5]. In so doing, it became imperative to develop the participatory technology development (PTD) approach and integrate it into the community organizing strategy[6]. This paper attempts to explain and abstract the experiences from this perspective.

BACKGROUND

Since 1972 until about the early part of this decade, the Central Plains of Luzon has been the development breadbasket of the Philippines. It is here where the numerous government development programs heavily financed by the World Bank[7] were implemented. The Pantabangan Dam[8] - Upper Pampanga Irrigation System, the Land Refora, and the Masagana 99 credit and production programs[9] are just some of the major development efforts initiated by the Marcos government.

Prior to the launching of these programs, the rice and corn lands of the Philippines Mere the hotbeds of dissent. This is where the Hukbalahap rebellion took place in the 1950s and early 60's. Dissent was never pacified in these areas despite the arrest of most of their leaders. Thus when Marcos declared martial law in 1972, it was imperative that the rice and corn areas received the attention of the government for all its years of seeming neglect."[10]

ACES COs entered the area in the Middle of 1978[11]. Right away, the expressed problems of the farmers were 1) their huge indebtedness to both formal and informal lending institutions - the average was P 25,000 per farmer; 2) unfinished and unfixed drainage and lateral irrigation canals, 3) the slow and bureaucratic implementation of the land reform program[12]; and 4) the increasing poverty because of poor returns on their harvest.

Socio-culturally, the farmers were cynical of change agents and extension workers. There was a general feeling of apathy and powerlessness to effect change in their conditions. They were dissatisfied with the way development programs were being implemented[13]. They can voice this sentiment individually to persons coming from the outside. However, they are unable to express it to the persons in authority concerned. They either hold back or totally back down on their position. Their situation is clearly a case of intense paternalism, and dependency brought about by 400 years of colonial rule and carried over by post war governments. Political independence of the country did not bring back local initiative and self reliance to the broad masses. It even reinforced docility, apathy, paternalism and dependency.

It is in this context that ACES decided to concentrate its efforts, i.e. to bring about a situation where small farmers can actively participate in determining what is best for themselves.

The ACES appropriate technology teas (later on they were also called COs) entered the 8 villages in 1981.[14] This was after ACES COs have been catalyzing actions with the farmers for about two years and a half. I categorize our methods of intervention into three types. (see diagram 1). The first is called pressure tactics. This aspect of the community organizing Methodology was the only intervention made by our group between the periods August 1978 until the end of 1980. This is where farmers' action is geared towards mobilization to resource agencies that cause a particular community scale problem. It meant demanding and negotiating from the institutions the services required to resolve the complaints. This particular method of organizing is very effective in bringing people to action. It gets the affected people out of their culture of silence and apathy. This approach is effective in building small issue based groups (20-30 farmers) that focus on a particular urgent need/problem. As there are felt problems, there can be as many groups more often interlocking in their membership. The key to becoming members in any of the groups is, one's readiness to act together with other affected members of the community.[15] This is the agency's method of empowering small farmers along socio-political lines.

The second type is called resource base expansion. This is incorporated in the agency's overall strategy for development when the appropriate technology team was fielded in 1981. The team's role was to further catalyze actions among the newly organized groups or individuals along socio-economic lines.[16] Resource expansion means bringing back the know how of acre diverse productive use of the land other than just planting rice. It is this effort where the details of the PTD approach was developed. This is a method of empowering small farmers along socio-economic lines.

The third intervention is the conduct of a participatory research on farmers' perception of the current farming system. This study was a direct response to the farmers' chronic complaint, that despite the implementation of numerous government programs they still find themselves poor if not poorer than before the programs were launched. This method served as a tool to enhance the conceptual comprehension of the systemic and complex nature of the present farming system.[17]

Currently, ACES community organizing methodology consists of all of the above. (For some time, we termed this as complementation). Because of this, the level of action not only includes the micro farm situation but also involves a more national and holistic dimension. The desire to develop alternative technologies to replace the current system takes on a national character. Because farmers have experienced mobilizing themselves to negotiate access to resources, local scientist inputs are solicited. This is to augment and substantiate their actions and demands towards this end. Linkages with other communities are established in order to realize greater power in numbers, experiences and wisdom. Consequent farmers' actions are directed simultaneously towards socio-political and economic policies, structures and institutions of Philippine Agriculture. In the same breath, there are actions to concretize in community level practice the desired alternative farming system appropriate for small Filipino farmers. The PTD approach likewise took on a macro character.

THE PARTICIPATORY TECHNOLOGY DEVELOPMENT APPROACH (PTD)

With this background, I would like to go into the details of the approach.[18] The PTD consists of seven (7) major steps, namely:

1. Problem identification and analysis;
2. Prioritization of the people's solutions to their problems and the introduction of certain technologies as possible solutions although,
   it may not be within their realm of experience;
3. Provoking of an experiment on one or more solutions of their choice;
4. Facilitation of the conduct of the experiment/s;
5. Evaluation;
6. Replanning for use (then return to step 2; but if the result is rejection of the technology, start from either step 1 or 2, as the case may be.) and
7. Reflection.

Prior to undertaking any of the steps just enumerated, it is imperative that the (CO) has fully integrated in the community. This implies that the CO has lived in the place on a full time basis just like the rest of its members. After a certain period familiarity with the people, their culture, habits, wants, aspirations, and problems has been achieved. Likewise, all data pertinent to the particular task in the area have been gathered.

Problem identification (step 1) refers to the process by which the CO gathers the people's opinions regarding their major problems which can be resolved through certain technologies. The problems pinpointed are analyzed and prioritized. This will then serve as the basis for extensive discussion in the succeeding steps.

During the second step, the CO tries to learn about all the possible solutions to the problems which the community folks perceive. This is done by engaging in conversations, small talks, caucuses with the local residents. By just posing appropriate questions it is assured that the people are allowed to think for themselves. After exhausting all their ideas, the CO shares other types of technologies some of which may be beyond the experience and knowledge of the people. They are left to decide what must be done about the problems given all the options discussed. No further mention is made regarding the technologies mentioned by the CO until the members of the community themselves ask for more information. The extent of each individual's interest in the appropriate technologies in question is gauged. He or she makes sure that these technologies are extensively compared with the rest of the other solutions they have already suggested.

After all the data have been clearly laid down, the people select the technology they deem best and most appropriate to their situation. Then the CO provokes the pursuance of an experiment (Step 3). Those who have signified their interest and intention to join in are motivated to meet formally and plan out the details of the task. Informal groupings are formed and assigned the responsibility of conducting the actual experiment.

Facilitation (step 4) starts upon the commencement of the experiment proper. The CO makes sure that everyone is aware of the reasons for the exercise. As much as possible, the experimenters are guided to stay away from readily available or packaged remedies as the experiment is going on. The people are encouraged to make realistic and practical innovations along the way. All results are recorded, systematized and synthesized for better understanding. They are discussed and carefully analyzed in a series of formal and informal for a culminating into an evaluation session.

The main criteria for the people's evaluation (step 5) vary from one technology to the other. Most technologies are evaluated from the economic point of view. To illustrate, the small scale fishpond was rapidly accepted as appropriate since it proved to be a good source of additional income. It also incurred very little expense. Moreover, existing skills are tapped, fish food locally produced and always available. This is contrasted to the experiment on soil bricks (meant to scale down the cost of housing materials). The latter seems less appealing due to its lack of potential as a Source of supplemental income.

Once the experiment succeeds and the people concerned decide to make use of it, careful planning is done (step 6). Regular discussion fora are held. This is to ensure that further development of the technology benefits the individuals interested in adapting it, and that no one monopolizes the know how.

The reflection processes[19] are group discussion sessions that focus on the rationale behind the activities undertaken by the farmers. Particular attitudes, lifestyle, beliefs, fears, and apprehensions are expressed, enhanced or inhibited, reinforced or negated. Reflection develops the ability to conceptualize and theorize from all the actions undertaken individually and collectively. it gives them a clearer understanding of the various forces operating in the environment - local, national, international, and within themselves. They learn what to enforce or negate. At this stage, the farmers realize the processes they have gone through. The experiences are further related to the historical and broader context of the nation.

The reflection sessions summarize the main ideals and principles of appropriate technology and that of inappropriate technology.

The importance of PTD is the conscious development of attitudes and values of self-confidence and less dependence on outside forces. The people realize that they have the power within themselves to solve their own problems. They learn that the processes which they have gone through are their tools in solving any other problem that may confront them.[20]

I will discuss briefly two cases where this approach was developed and refined. The first case[21] involves individual and small group experimentation to immediately answer the perceived adverse effects of the prevailing rice monoculture, capital intensive, synthetic agriculture. The second case describes how the farmers took part in a participatory research to pinpoint the root cause/s of their current poverty. Having identified and understood the causes they proceeded to organize an elaborate national validation of their observations. This centered on the adverse effects of "modern agriculture" typified by the use of high yielding variety of rice (HYVs). Immediate and long range initiative in partnership with the local scientist is

developed. This paved the way for a program to develop alternative farming systems. This is done initially in the 8 Nueva Ecija villages. Later on, it will expand to the rest of the farmers organizations that participated in the national consultation. The overall direction and orientation of Philippine agriculture may in time be influenced by this initiative.

CASE 1: "WE NEED MORE INCOME"

These words summarize the main activation of the farmers in undertaking with the COs new activities that essentially rediscover the different uses of their resources, namely, land, the river, agricultural waste, available skills and the like.

In the first village, Malabon Kaingin, the COs direct intervention started with a seminar/workshop among the community residents. They pinpointed fishpond, vegetable raising, hog raising, and bamboo and ipil ipil planting as economic activities which they want to undertake. The farmers were grouped according to the need they want satisfied/answered. Each group then went through the nitty-gritty details of planning for an experiment. Dates were set for the experiments to commence.

The bamboo and ipil ipil experiments did not continue after the first planting. There were not enough vacant lots to plant them. The bamboos were meant to be a source of building materials especially for the younger generation. The ipil ipil was intended to be the source of firewood, feeds and supplementary fertilizer. The group ended with a discussion on the finiteness of their land resources and the need to learn how to maximize its use.

The vegetable raising did not reach the implementation stage. Because of the irrigation system which they do not control there is not enough land to plant vegetables on a more commercial scale. It is too risky because when the irrigation water starts flowing, it will flood the fields and drown the plants. However, backyard raising for those who have access to a piece of land was looked upon as an alternative. They were left on their own to implement it.

Hog raising met a similar fate. The main block was the capital involved. One has to buy good breeds, feeds, and shelter for the hogs. This was too much for their meager income. They planned to request the Bureau of Animal Industry (BAI) for a seminar on the latest technique of hog raising. They thought that this could be a step to asking for loans from the said institution. They underwent the seminar only to find out that BAI has stopped issuing loans on hog raising due to low repayments. There were talks to grow alternative feeds and use other housing materials. However, their computations show that it will not bring down the cost significantly. Besides, they will have to allot a portion of their fields to raise the feeds. This is a direct competition to growing their rice crop.

The significant initiative that succeeded in this village was the fishpond experiment. "Juan Mendoza and his two sons started digging manually one tenth of a hectare of a rice field to accommodate three equal-sized fishponds. In one week, the ponds were ready for seeding. With P150.00 worth of fingerlings, the first three fishponds in Malabon Kaingin were built. The rest of the fishpond group maintained a wait and see posture."[22]

A typhoon struck a month after. The ponds remained intact while soon to be harvested palay got soaked in the floods. Thus the following month five more ponds were built. Six months after, 17 more were added to the list. During this time, technical discussion for a were held to summarize the experiences of the experimenters. They compiled their report which they shared with other farmers interested in knowing the do's and don'ts of fishpond culture.

The farmers continued their research and development. This time they looked at other water dependent crops/species that may thrive well in the ponds. Some of the crops tested were taro, other species of fish, and rice. vegetables were planted around the enlarged dikes.

Meanwhile in three other villages, small experiments were being conducted. Mushroom culture, carabao pool for landless workers, fish cage, indigenous harrowing tool production, soil cement brick making, co-operative store, traditional varieties of rice and many more were tried. These initiatives were met with varying degrees of success and failure. (Success and failure here means that the farmers proclaim for the moment, a certain technology as either appropriate or inappropriate). Consequently, the success of the fishpond in Malabon Kaingin caught up with the other villages. The farmers of these villages undertook their own process of appropriation of the fishpond experience.

The underlying purpose of this part of the PTD process is to bring back or affirm the farmers' inherent ability to conduct their own experimentations.[23] It is essentially a process of appropriation. With the least technical input from the outside, they were able to determine systematically whether a particular technology is appropriate for them or not.[24] The role of the COs is merely to facilitate the emergence of the knowledge. He or she cultivate the farmers' ability to produce the observations necessary to make a judgment on a particular experiment. In a number of times we were tempted to teach and in some cases, we did.[25] Despite this the patience of facilitating the above prevailed. And because of this, the technical information is better appreciated and remembered.

The expressed goal of diversifying their land became the main aspiration which farmers want to work on. But structural impediments were the main stumbling blocks. Structural impediments to them meant the inability of government institutions to respond to their immediate and long term needs. In their experiments, there seems to be more inappropriate that appropriate ones. Despite some successes, monocrop agriculture still prevails. Synthetic farming and dependence on its capital inputs still predominate. Though some of the appropriate ones (fishpond, carabao pool, mushroom raising, co-operative stores, traditional rice varieties) proved to be a source of additional income (or imply lesser cost in the daily family or farm budget), it did not really tackle systematically the core of their farming system's problem. They later found out that the root cause of their problem is the continued perpetuation of the rice monoculture through the use of capital intensive HYVs. Ironically, the government even facilitated and became the main vehicle for the perpetuation of the system. The next case tells of the parallel action which the farmer's undertook in order to confront the more fundamental structural cause of their poverty.

CASE 2: WHAT AILS THE PHILIPPINE RICE FARMING COMMUNITY?[26]

This question summarizes the quest of the farmers to fully comprehend the problem of their community. If you notice this is the first step of the PTD process. As I mentioned earlier, they wanted to understand why despite the extensive implementation of the government program on modern agriculture, they still remain poor.

In the second quarter of 1982, an ACES research team requested the farmers to participate in a study. It was aimed at determining whether farmers benefited from the HYV technology or not after almost 10 years of its extensive use. We asked them to compare their farming practices and expenses during wet season of 1970 and the wet season of 1981. Four specific aspects of the people's lives were examined: the economic, technological, ecological and socio-cultural aspects. Government programs supportive of the HYV technology were evaluated by the farmers and documented by ACES.

ACES drew up the questionnaire in order for the data to be systematically and scientifically compiled. Seventy one (71) respondents were interviewed representing about 20% of the population. Group discussions, among those not interviewed, were also utilized to augment the information using the same questionnaire. The group discussions proved effective in counterchecking farmers' recall of information about their agricultural practice in 1971.

The results were tabulated and presented to the farmers. (By this time, the farmers in the 8 villages federated into a single organization called Diwa ng Magsasaka, or Farmer's Spirit.) Insights and interpretation of the data were solicited from them. ACES presented its own preliminary observations. The information, insights, analysis and recommendation of the research are highly sensitive. Thus ACES and the farmers deemed it necessary and important to validate their observations with the experiences of other farmers throughout the country. Thus a process of consultation was planned.

To prepare for the validation session, farmer-presenters were trained in presenting the charts and tables. Appropriate visual aids were developed attuned to the graphic mode of farmers.

Validation of the data started in the first half of 1984. The presenters took turns in presenting the findings of the research in their villages. Other insights, recommendations, analyses and viewpoints were solicited to substantiate the data. The presentations were also in effect reflection modules. They increased the understanding of the farmers about their community problems and the relationship to national policies, systems and structures.

Other farmer groups were consulted.[27] An abridged version of the original questionnaire was formulated. This was done so that the Nueva Ecija results would not influence the outcome of the discussion of the other farmers' organization. The questionnaire was sent to about 50 other groups for discussion. The results were synthesized in a series of regional consultations. Positions from Mindanao, Visayas and Luzon were formulated.[28] A national consultation dubbed as BIGAS, (National Consultation on the Issue on Rice) was held in July 1985 to consolidate the analyses and synthesis of positions and recommendations.

Simultaneous to the above processes, the local scientists were consulted. They provided the scientific basis for the analyses, positions and recommendations of the farmers.

The synthesized position was presented to the authorities concerned including IRRI. However, they fell on deaf ears. The frustration was very great. The farmers felt that at this point it is best to start doing more things by themselves. The local scientists committed themselves to support their action.

ACES organizers facilitated a series of meetings between the scientists and farmers. The Farmer Scientist Partnership For Development Inc. was conceived and organized. The basic purpose of this organization is to bring back genetic diversity[29] of rice and other crops into the farms. They will experiment on various practices of organic farming, intercropping and other combinations, to be done initially under irrigated lowland conditions. Biological control and inputs, a number of which have been discovered recently by the local scientists, will be tried.

As of this writing, the first batch of 41 non-IRRI varieties of seeds were systematically planted for propagation and characterization. This was achieved in a three hectare experimental farm in one of the 8 villages despite the lack of financial support. The seeds came from the different farmers' organizations that were present in the national consultation. Farmers are taking turns in observing the specific characteristics of the varieties. Once multiplied and characterized, the seeds will be sent back to the 12 other centers. These centers are envisioned to form a network of community seed banks and center for organic agriculture. Alongside this effort, scientists and farmers will determine the desired parentage of new rice seeds that may be bred. These are cultivars that are climatic specific or even farmer specific.

Actions on the other components still need to be worked on. With or without support from the government, the planned activities will go on.

It is important to note that in this context the farmers are not only from the Diwa ng Magsasaka. They include other rice farmers nationwide. The central station for the Farmer-Scientist Partnership project is situated in one of the 8 villages. Other centers will start to operate as soon as the 41 non-IRRI varieties are harvested. Meanwhile, farmers groups from other parts of the country are conducting their own experimentation on diversification. Horizontal exchange of experience will commence once some proven viable technologies are delineated.

DISCUSSION OF RESULTS

Both of the cases discussed outline the meticulous details of the seven steps of the PTD approach. The first is on a micro level of experience and actions, while the second is on a macro level. The latter looks into the interrelationships of various socio-economic, political and cultural forces that affect a farming community. Both examples affirm the farmers' experience and perspective. The process enforced the belief that the one who has extensively used a technology has the right to proclaim it appropriate or

not. The two centered on the process of appropriation. However, the second went on further to look at appropriate products. While the first may still be co-opted by the system if it turns out products that would compete with existing market forces, the second may bring out more socially oriented products.[30]

The actions of the farmers in both cases were geared towards diversification. Initially, it was an instinct to use the land for other crops. In the second case, the activities were not only geared towards diversification of crops but also towards the return of genetic diversity in the rice crop itself. This was the situation the communities were in prior to the advent of the two crop irrigation systems and the use of high yielding varieties of rice.

There are definitely a number of other lessons that may be learned from more than five years of farmers participation. I would like to point out a few. Firstly, farmers will not take development work into their own hands if the political structure is capable of responding creatively to their needs. The general feeling one gets in dealing with the resource agency is that they do not really want the farmers to improve their lot. It seems that the government wants them to be chronically dependent on the institution for support, rather than be self reliant. Perhaps, this speaks of the political system of patronage and paternalism which very much predominate our society.

Extension workers, technologists including scientists involved in development work must learn to be elicitive-catalysts. I would like to contrast this model with that of the prevailing one which I term as prescriptive- catalysts. Elicitive-catalysts approach the farmers with only a general program and orientation in mind. Prescriptive-catalyst, on the other hand, usually have a specific project to deliver. The former are flexible in molding and evolving specific projects shaped by the farmers' minds and hands. The latter are confined to the limited parameters of the project, often unable to flow with the diverse felt and real needs of their clientele. Prescriptive catalysts, thinking of themselves as more learned would tend (unwittingly in most cases) to impose their own world view, analyses and solutions to the "poor and unfortunate ones." Elicitive-catalysts refuse to impose their own description of the world. They would instead, draw out from the clientele their own analyses, world views and solutions and adapt them as their own through creative dialogue. This way they affirm that being "poor, unfortunate and unschooled" do not necessarily mean, absence of their version of the world or an analysis of events and situations, much more an indigenous solution.

Many of today’s development workers employed in agencies both local and international, practice prescriptive catalysis. This is so despite the fact that most of them espouse the necessity of people's participation. However, it seems that they have adopted people's participation without the corresponding change in their attitudes, value systems and structures within their organizations. This subject is a whole range of issues in itself which I would like to write about at an appropriate time.[31]

Lastly, since this is a gathering of distinguished scientists and technologists involved in the "development" of third world countries, I would like to express the following. Perhaps, this is addressed more to third world individuals present here today. We should learn how to unlearn

the social genes which the present society, particularly our educational institution, have programmed in us. We should undergo a process of appropriation ourselves. This is important most especially with regards to the processes and knowledge we got from western influenced universities. There is an "enemy" within us. By our basic training, we are secondary carriers of western modernity that have taken roots in third world societies. We are short of being advertisers or promoters of their technologies more often inappropriate to our needs and conditions. This, I believe, is one reason why our people's indigenous innovative capability is stunted.

I would like to end by quoting an author who opened my eyes into the true meaning of appropriate technology for developing countries.

> "*... appropriate technology should first and foremost be an indigenous creation of the developing countries themselves, and the central problem they have to face is that of building up an indigenous innovative capability and not that of importing more foreign technology,*[32]

- Nicholas Jequier

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NOTES

1. Paper presented at the Sixth Annual Farming System Research and Extension Symposium: Food and Feed., October 5-9, 1986, International Agricultural Programs, Kansas State University, Manhattan, Kansas.

2. The views expressed in this paper are my own and do not necessarily reflect the thinking of the agency.

3. A non-profit Foundation devoting itself to the organization of small farmers in the rice producing provinces of Central Luzon.

4. The 8 Nueva Ecija villages are, Iabunia, Malabon Kaingin, Marawa, Pamacpacan, and Sta. Rita in Jaén; Hache Romero and Carmen in Zaragosa; and Rajal Centro in Sta. Rosa.

5. In July 1978, ACES was asked by an IRRI (International Rice Research Institute) anthropologist, Dr. Grace Goodell, to participate in a research project. Dr. Goodell postulated that the high yielding variety of rice can best benefit small farmers if they are organized. She wanted to know which organizing approach would best bring benefits to the farmers. Two approaches were considered: the bottom up and the top down. For the latter, she studied the compact farms of the Economic Development Foundation or EDF. ACES was contracted to provide the experience on the other. At that time, ACES organizers were trained on the pressure tactic/ action-demand strategy, a method used by Saul Alinsky in the Ghettos of Chicago. The project was initially set for 28 months and later extended to 60 months. The Ministry of Agriculture provided the financial support for the local component of the project.

6. The community organizing methodology is a set of principles, knowledge, attitudes and skills manifested in a nine (9) step organizing process. This has been indigenized and adapted to rural conditions since it was first introduced here in the early 70s. See Dionisio, E. 1985 Towards Relevant and Effective Community Organizing and Malaya, F. 1979. Organizing People for Power. for details of the organizing experiences in the Philippines.

7. See Bello, W. 1983. Development Debacle: The World Bank in the Philippines. Institute of Food and Development Policy. San Francisco, CA. USA. and Jose V. 1982. Mortgaging the Future: The World Bank and IMF in the Philippines. Foundation for Nationalist Studies. Quezon City. for the detailed discussion on the adverse effects of the World Bank's programs in the Philippines.

8. The Pantabangan dam is one of the largest multipurpose dams in Asia located in Pantabangan, Nueva Ecija. The Land Reform program was implemented through Presidential Decrees No. 2 - declaring the entire country under land reform, and No. 27 limiting the scope of land reform to rice and corn lands. Masagana 99 is a non-collateral credit and production program. Farmers must use capital intensive inputs such as HYV seeds, fertilizers, pesticides, machineries in

order to avail of the loans. It was implemented extensively in all rice lands from 1974-78 but was gradually stopped due to low repayments. See Ofreneo, Modernizing the Agricultural Sector, pp 98-127.

9. See Mclennan, M.S. 1980. The Central Luzon Plains: Land and Society on the Inland Frontier. Alemars-Phoenix Publishing House Inc. Quezon City, p 102.; Carrol, J. S.J. 1972. Sources of Social Unrest, p. 13-27. In The Philippine Economy in the 70s: Prospects and Problems of Development. Institute of Economic Development and Research, University of the Philippines, Quezon City. and Constantino, R. 1975. A Past Revisited. Insular Packing Corp. Manila, p. 579-380.

10. Marcos, F. 1972. Presidential Decree 27. Ministry of Agrarian Reform. Quezon City, Philippines.

11. Five (5) community organizers were initially fielded covering 4 villages. These areas are Marawa, Iabunia, and Malabon Kaingin in Jaen and Hache Roaero in Zaragoza. The community households to organizer ratio is about 150:1 on the average.

12. ACES came out with three (3) case studies describing how organized actions of farmers tackle the problems on credit, drainage and irrigation and the implementation of Land Refora. See Modina, R. Farmers Battle a National Irrigation System, the Credit System and Small Farmers, and A Critique of the BCLP Valuation of the Land Reform Program.

13. See Juliano, C. 1980. Small Farmers Organization Project in Review. ACES Foundation. Quezon City, Philippines.

14. One AT organizer (later on they were also called COs) was initially fielded in one of the 4 original villages, Malabon Kaingin. Two others followed later and were fielded in Marawa and Sta. Rita. The latter wasan expansion area.

15. Small issue-based groups after sometime are organized into a barrio scale association. Barrio organizations are federated into what we call a people's organization (PO). Barrio level organizations focus on local issues while a PO tackles the more complex and systemic nature of agricultural issues.

16. See Tan, J., V. Bagasao, A. Carpió and R. Dalisay. 1981. Towards a Participatory Technology. ACES Foundation, Quezon City. Philippines.

17. See Modina, R.B. Ridao, A.A. 1986. IRRI Rice HYVs: Seeds of Dependence. ACES Foundation. Quezon City. and _____. 1985. BIGAS National Consultation Proceedings. ACCI Hall. 16-19, July, 1985. ACES Foundation. Los Baños, Laguna, for the details of the processes and contents of the Consultation on the Issue on Rice.

18. This is a refinement of the approach discussed by Tan, J.G. 1985. Some Notes on Participatory Technology Development. IFDA Dossier 45:12-18.

19. Reflection was essentially adapted from Freiré, P. 1972. Pedagogy of the

Oppressed. Community Organizers use it as part of the organizing process to link local issues to a national awareness and understanding.

20. I would like to differentiate PID from the popular approach on self help in community development. PTD should always be looked upon in relation to the two other components in the community organizing strategy: pressure tactics which tackles the socio-political arena and participatory research which provides the tools for greater understanding of the inter-relationships of micro and macro systems and among the different systems within a society. PTD should never be taken out of this triad.

21. See Bagasao, V. 1983. Developing Technologies at the Grassroots, an Experience in People's Participation. ACES Foundation. Quezon City. and Villavicencio, V and Tan, J. 1982. People's Hands and Minds Shape Technology. AT/BO Journal on Appropriate Technology 1:12-13.

22. Ibid., Bagasao p. 6.

23. Farmers do experiment on their own with or without the supervision of technicians. However, this initiative is seldom acknowledged. It may even be downgraded because scientists and technicians do not recognize the inherent capabilities of farmers.

24. The usual attitude of farmers when they feel or experience a particular technology (especially a new one) as inappropriate is simply to avoid it use. This decision in some cases, is done without much systematic analysis. In such instances, the reason for rejection or non use is based on imaginary fear which can be overcome or set aside by more rational discussion. See Bagasao, V. Op cit for a discussion of this point vis-à-vis the fishpond experiment.

25. See Feder, E. 1983. Perverse Development. Foundation for Nationalist Studies, Quezon City, Philippines, and George, S. 1976. How the Other Half Dies: The Real Reason for World Hunger. The books describe with authority why small farmers continue to be poor despite of and because of the Breen Revolution.

26. One example of our intervention to teach was when we had to persuade them to avoid the habit of using imported (i.e. buying) inputs. We told them that buying inputs aggravates their exploitation, makes them oblivious to indigenous materials and resources which they can use, and may deprive them of using their abilities to discover other means.

27. 31 Farmers Organizations and their support groups eventually participated in the whole process out of about 50 or more who were invited. They represent a total membership of about 75,000 farmers nationwide.

28. Luzon, Visayas and Mindanao are the three main island groupings.

29. See Mooney, P. 1979. Seeds of the Earth: A Private or Public Resource' 1979. International Coalition for Development Action, London. Mr. Mooney points to the fact that the extensive use of HYVs contributed immensely to the disappearance of traditional varieties, a major cause of genetic erosion.

30. See Gonzales, Raul. 1982. AT in the Eighties: In Search of a Philosophy. AT/80 Journal on Appropriate Technology. 1:2-5.

31. In this issue, my basic premise is that third world countries do not need development aid especially from governments of developed nations and foundations sponsored by Transnational Corporations. Development aid is wittingly or unwittingly used to camouflage the continued exploitation of third world economies. What we really need is more equitable trade relations. I suggest that if economic justice can be mutually agreed upon, we need to implement a trade relation disproportionately in favor of third world economies for a certain period of time. This will allow time for the wealth extracted by affluent societies of the north to flow back to the poverty societies of the south. Poverty and affluence are two sides of the same coin. Thus development workers in international agencies must see through this reality. They have to train their attention to seek economic justice for third world nations in their own home.

32. Jequier, N. 1976. AT Problems and Promises. Part 1: The Major Policy Issues. AT Project of the Volunteers in Asia. Standford.

ACKNOWLEDGEMENT

I would like to thank the former members of the Participatory Technology Team of ACES for undergoing the painstaking process of appropriating the principles of appropriate technology to community organizing. Many thanks also to the team that followed through after ACES merged the PTD with its over-all organizing thrust.

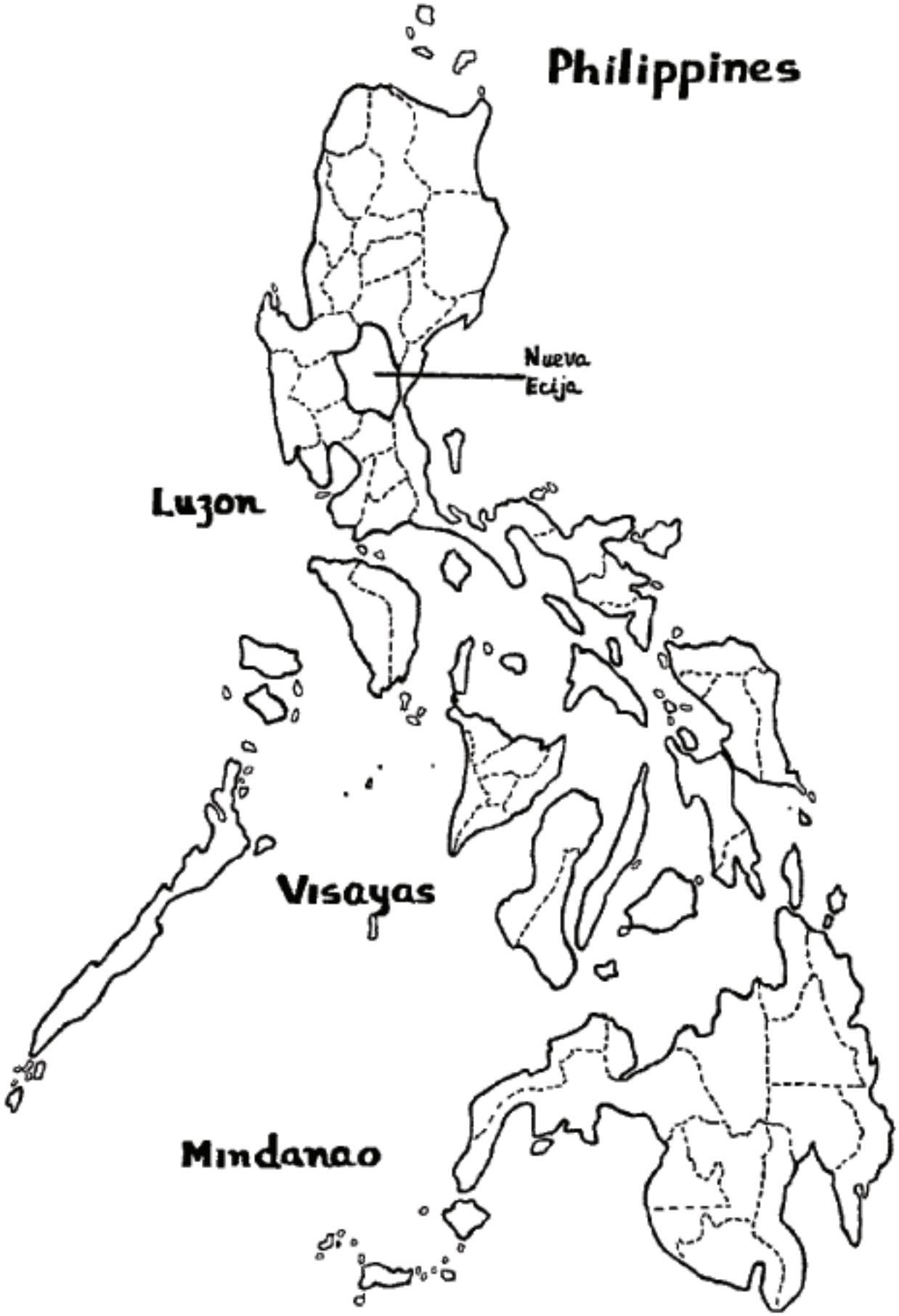
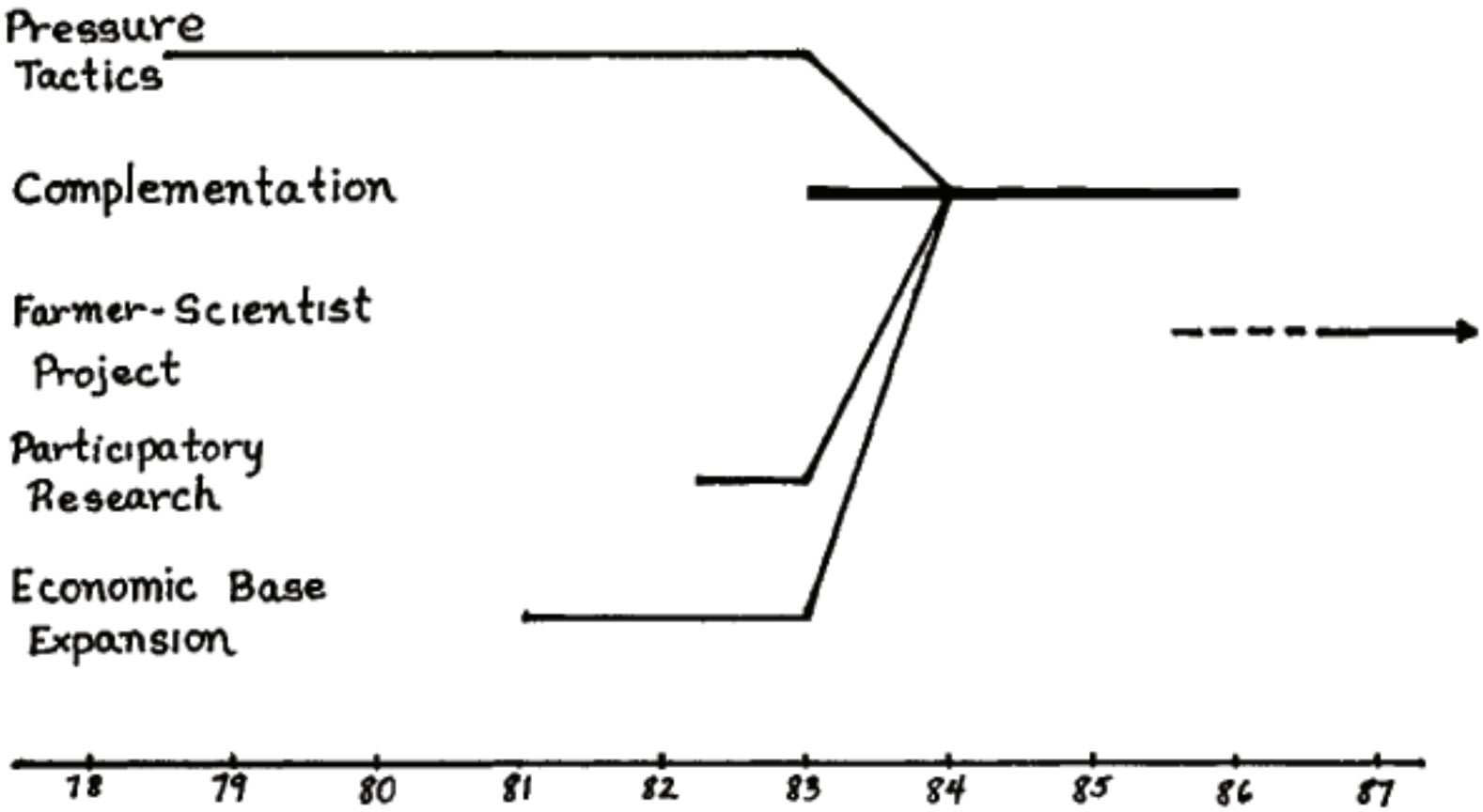

Philippines
Nueva Ecija
Luzon
Visayas
Mindanao

Diagram 1



Interventions

Farmer Participation in On-Farm Research and Extension: Some Farmers Still Say "No": Lessons from the Farming Systems Development Project--Eastern Visayas

Tully Cornick[1], Dolores Alcober[2], Raul Repulda[3] and Fatima Balina[4]

Introduction

There has been growing recognition over the last 15 years that improvements in rural and agricultural conditions in the developing world are dependent upon the increased involvement of small farmers in development (Whyte and Boynton, 1983). Concern for farmer participation in the development procesa in general (Cohen and Uphoff, 1977; Castillo, 1983), as a major consideration in irrigation organization and management (Uphoff, 1986), in the development of agricultural technology (Matlon et al, 1983; Ashby, 1984), and specifically in farming systems research (Richards, 1986), is now widely evident. Farmer participation is a given and important aspect of many development and farming systems projects, although the form and extent of that involvement varies greatly (Matlon and King, 1983).

Concern for increasing farmer involvement in the agricultural development process has been replaced recently with the more compelling concern of how to improve or make more effective farmers' involvement (Bigot, 1983, Kirkby and Matlon, 1983). It is the nascent awareness that the presence of elements conducive to farmer participation in the agricultural research process does not automatically lead to substantive farmer participation that has led one scientist to ask just "How Participatory is Participatory Development?" (Castillo, ibid.). The inclusion of farmers in agricultural development in a participatory framework brings to the forefront potential problems of communication, misunderstanding, ill-defined expectations of others, mistrust, conflicts in values and role perceptions--to list just a few--that also characterize the much discussed and still unresolved hiatus in communication between research and extension (Tuaopepe, 1986). Thus, one is not surprised to encounter FSR practitioners who still report encountering farmers unwilling to participate or cooperate (Barker and Lightfoot, 1985).

The task of facilitating farmer participation in FSR/E research is relatively well understood and well defined conceptually when participation is restricted to the conduct of on-farm trials. This holds true particularly when the sequence of researcher-managed and implemented to farmer-managed and implemented trials is followed and when trial design is formal and standardized, such as described by Hildebrand and Poey (1985). Similarly, to the extent that farmer participation is defined as occurring through the collection of information, either via formal surveys or rapid rural appraisal activities, the ambiguity of role definition, as least as understood by the researcher, should be minimal within the phases of diagnosis, problem identification, and design. Farmer involvement is direct, primarily consultative and "unempowered" (Lynch, 1985). In such a context, the research belongs to the researcher.

The issue of farmer participation becomes increasingly complex, however, as the scope of farmer participation is redefined to include the entire range of FSR/E phases, and as farmer involvement in the process shifts from a consultative to an empowered participation-in-decision-making mode. The addition of community or group alongside individual levels of involvement introduces new dimensions that also require consideration. The nature of the

1. International Agricultural Program, Cornell University, Ithaca, MY
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4. Dept. of Agricultural Educ. and Ext., Visayas State College of Agriculture, Baybay, Leyte. The Philippines.

social interaction among researchers and famers achieves a qualitatively different level. It is acre difficult to manage, although potentially more productive. It is at this level that the potential for misunderstanding increases. When farmer participation in a decision making mode is an integral part of the entire FSR/E process extending from diagnosis and problem identification through dissemination, the potential interplay of different levels and types of participation in each of the separate phases of FSR/E, and the possibility of problems arising within, increase exponentially.

Effective and culturally sensitive methods for incorporating farmer participation into an FSR/E process, which is itself still being defined, are at best inchoate and developmental. One does not need to resort to explanations of lip service paid to farmer participation (although it exists to some degree, one suspects) to explain the presence of nominal or enervated participation of farmers in the FSR/E research process. Upon careful inspection, differences between researchers and farmers in cultures, languages, expectations of desired outcomes, well intentioned but poorly implemented activities, and inappropriate technology are generally found to explain ineffective and unsatisfactory farmer participation.

Paradoxically, incidents of full and successful participation of farmers in FSR/E are not always easily explained, particularly when they exceed the intentions and expectations of the researchers. They do, however, offer fruitful areas of research and comparison with less successful efforts at farmer participation. Answers to the problem of developing the most effective methods and identifying determinants of high levels of substantive participation are frequently confounded by social structure and cultural norms that make overt manifestations of refusal to participate both unwise and inappropriate farmer behavior. As a consequence, the distinction between more and less successful efforts at fostering farmer participation are not necessarily readily apparent. This is particularly true during the initial period of work before concrete field activities are underway. The phenomenon of encountering farmers, individually and collectively, who meet government and expatriate researchers and extend the expected approval and socially acceptable nominal agreements is common to all agricultural development workers. Nevertheless, even the audibly uttered "yes" may well mean "yes, I hear you", but not necessarily "yes, I agree and consent to do...". The interpretation of silence as assent may also lead to similar confusions. Initial evidence of an inadequate level of farmer participation may be glossed over by individual and community face saving behavior suggesting agreement and involvement that may not exist.

The use of inducements or material incentives to encourage farmer participation similarly contributes to situations where farmers not wishing to participate in the research activity may do so to participate in the incentives. Both situations can lead to spurious forms of participation that may not be readily apparent until a project is fairly far advanced in the research process and researchers suddenly find themselves unexpectedly confronted with poor participation. Put simply, the problem of discriminating between spurious and substantive participation of farmers is salient when trying to enhance meaningful farmer participation.

In the present paper, we present several methods used in the Farming systems Development Project — Eastern Visayaa (FSDP-EV) to foster farmer participation in the research process. We then describe two separate cases of "empowered" farmer participation. Despite roughly parallel processes of involving farmers in decision making and similar levels of farmer involvement, the results from the two cases are markedly different. In one instance,

farmers largely reject the technology and reduce their degree of involvement with the research; in the second farmers quickly assume control of the trials themselves, transferring the technology to their own fields despite second generation problems. They then become pivotal figures in a "farmers teaching farmers" extension outreach program.

The Farming Systems Development Project and Farmer Participation

The Farming Systems Development Project in the Eastern Visayaa region of the Philippines was initiated in 1982 to develop technologies appropriate to the situation of small-scale upland farmers of the area. The project is implemented by the regional Ministry of Agriculture in conjunction with the Visayaa State College of Agriculture. Cornell University provides technical assistance to the project. Six relatively distinct "municipalities" or counties were selected as research sites. Each site was chosen because of a predominant crop base and characteristic agro-ecology representative of other areas in the Eastern Visayan region. In mid-1982 4-6 person site research teams began working in the designated municipalities and surrounding "barrios". Each team consisted of two experienced MAF municipal agricultural officers, each previously familiar with the actual or similar site area, and two recent college graduates with little prior experience. Some sites also hired research assistants from among the local populace.

Although a few varietals, poultry, and livestock feeding trials were set up in the sites, a series of "Sondeos" conducted, and site teams became familiarized with the area and farmers early on, the first sustained research was not initiated until early 1983 following a training workshop with local farmers in attendance. This was the first event of many to follow in each of the sites in which project management and site teams actively sought out farmers for their input into the development of research agendas. Farmer participation in various forms and with varied effect was to characterize project efforts over the next several years. Site efforts to involve local farmers in the research process from diagnosis and problem identification onward took on several forms. These included farmer meetings, informal conversations and interactions with farmers, informal focused farmer surveys, and the use of incentives. Each approach was utilized in varying degrees from the beginning. Over time, several of them became relatively routinized and structured.

Farmer meetings were initially called on an "ad hoc" basis in all sites. Depending upon the breadth of area and number of farming communities covered by each site team, farmers attending the meetings varied in composition from the co-operators and a few interested onlookers to the membership of an entire community. After the first year, monthly meetings of site staff, farmers, and staff providing technical assistance became a pattern in sites across the project.

Casual, directed conversation between researchers and farmers as they met and worked together provided one major form of farmer input before regular farmer meetings became established. After farmer meetings were introduced, these relatively unstructured interactions between farmers and researchers often became the forum for the expression of individual concerns and opinions not reflected in public settings, the "one-on-one" basis of this interaction frequently generated substantive feedback long before it emerged in public meetings.

Focused informal surveys were developed to elicit farmer feedback on specific problem areas investigated by researchers. Over time, as formal

sampling frames were utilized more heavily and written questions framed ahead of time, this form of farmer involvement became much more structured.

Finally, the use of incentives including the distribution of livestock (goats and carabao), seeds and planting materials, chemical inputs, and small amounts of credit was common in all research areas of the project. The concession of incentives and their distribution to specific individuals with some amount of fanfare meant that incentives and farmer meetings were associated events, virtually inseparable from each other in some areas. The mixture of the four techniques of encouraging farmer involvement in project activities was different for each site. However, the overall pattern in each of the sites had sufficient commonalty with the others. Hence we argue that the quite disparate results we find in the two case studies below are not attributable solely to gross differences in opportunities for farmer participation across the sites. We feel that the differences in the quality of farmer participation reflect subtle differences in the form in which the farmers' participation was engendered and in the communities of farmers themselves. Significant differences in the overall suitability of the technology tested is also considered a major contributing factor.

Establishment of Leucaena hedgerows in Villaba, Leyte

The decision to work in the "sitio" of Barangbang lying some nine kilometers from the "población" or municipal seat of Villaba was made early in the FSDP-EV's establishment while discussions about working in upland versus lowland areas were still underway. The site team chose to concentrate its efforts in Barangbang, a community of no more than fifty households. This was in keeping with the project's decision to focus activities in upland non-bunded agricultural areas.

Entrance to Barangbang is gained only by foot or beast of burden, following a winding, steeply climbing footpath for a kilometer and a half. The "sitio" lies in a natural watershed less than two miles across if measured at the top of the ridge. The barren and steeply sloping sides drain into a small flat valley and then out into the larger lowland area containing the barangay Cagnocot and the areas controlled by the local "hacienda".

Part of the "hacienda" prior to coming under the Agrarian Reform, the steep slopes of the basin show the effects of continued cultivation over many years. Once-extensive fields of sugar cane have been replaced with the fields and pasture areas of small-holder agriculture. Presently, whitish outcroppings of the calcareous C horizon spot the rugged and broken slopes. Only the bottom land, the repository of the surface soil from the eroded hillsides, presents a visual impression of fertility.

Following a protracted and sometimes violent struggle initiated by the Agrarian Reform movement, the slopes and bottom lands of the basin were transferred from the hacienda to the control of forty five families of small holders. This land base is becoming further fragmented as children of the original holders marry and set up independent households and holdings. At the beginning of the project, average land holding per family averaged .9 has. and total farm sizes ranged from 2 plus hectares to less than half a hectare on the smallest farms (See appendix 1). Nearly all farmers are holders of Certificates of Land Transfers, with prospects of meeting their land amortization payments and becoming fully titled owners of the land.

The Barangay Captain from Cagnocot facilitated access into Barangbang by introducing site staff to one of the sitio leaders. This leader then became

instrumental in recommending other farmers who might work with the site staff. these farmers in turn suggested other farmers whom they felt might be interested in working with the project. This process of farmer selection by referral enabled the project to identify nearly a dozen farmers as co-operators while the research agenda was not yet finalized.

Declining soil fertility and erosion were mentioned repeatedly as problems, both in the training workshop held by the project in January, 1983, and in discussions with farmers in Barangbang held before and after the workshop. During the workshop a tentative proposal to test a new variety of Leucaena ("Ipil-Ipil") in hedgerows grown along the contour with various patterns of intercropped corn and peanut followed by upland rice or sweet potato was developed. In subsequent discussions with farmers about the proposed experiments, they expressed reluctance to concede scarce land area to the Ipil-Ipil hedgerows. On the other hand, the proposed test cropping patterns of corn and peanut or upland rice were favorably accepted, perhaps because they did not deviate significantly from the patterns grown by the farmers.

The head of the site research team was a MAF technician who had undergone special training in the establishment of Ipil-Ipil hedgerows on the southern island of Mindanao less than a year before. He took special pains to convince farmers of the benefit of the leucaena hedgerows, showing them pictures of hedgerow establishments and providing figures of expected returns in increases crop production. A senior Ministry official from the national capital suggested the project sponsor a farmer field trip to see established hedgerows in similar ecological conditions on the neighboring island of Cebu.

Nine farmers of the original twelve who indicated interest in working with the site staff in the field trials were sent to Cebu along with several project staff. They were to view Cebu farmers working with several different forms of Ipil-ipil hedgerows and local crops in combination. Striking similarities in soil and topographical conditions, combined with the ease of communications made possible by talking with small-scale farmers speaking the same Viaayan dialect conveyed the potential benefits of the Ipii-Ipil hedgerows in a much more effective way than had been possible earlier. By the end of the trip, the Barangbang farmers had discussed the comparative advantages of the several different types of hedgerow technologies in use and had eliminated all but one as impractical in their situation. Both project staff and farmers were exposed, perhaps for the first time for all involved, to the very effective use of farmers as communicators and para professionals in the dissemination of information.

Following the field trip to Cebu, farmers were noticeably more willing to experiment with Ipil-Ipil and the cropping pattern trials. To finalize the research agenda before the start of the planting season, a meeting in Barangbang was scheduled. At the time, the only meeting place was the site of the "sitio" chapel, still under construction. Amidst the piled planking that would become the walls of the church, farmers and project staff met to discuss the proposed trials. More that 80 per cent of the households in the community sent representatives. In the discussions that followed, farmers argued for and won several changes in the proposed cropping patterns. Despite the concern of some project staff that entry into large trial areas with Ipil-Ipil be done cautiously because it had not been tried yet in the site area, the community-at-large was in agreement that hedgerows be a component of all three of the proposed cropping pattern trials. Each trial was replicated four times across farms.

In retrospect, the case can be made that Barangbang farmers had already moved ahead of the project in the research process. In June and July of 1983, when the project began to provide farmers with the materials to set up what were most representative of researcher-managed and farmer-implemented trials, the farmer co-operators were already deciding to establish their own plots of Ipil-Ipil hedgerows with seed remaining from the trial plots, in addition to modifying the actual trials. It can (and has) been argued that farmer enthusiasm for establishing the hedgerows, along with a less that rigorous implementation of the traditional cropping pattern trial methodology, interfered with the proper conduct of the research trials. It is true that the control plots in the trials--the farmer's practice--when formally established were also planted to hedgerows.

In the succeeding two years, the farmers' enthusiasm for the hedgerows continued to dominate the implementation of the formal trials. Despite heavy labor costs involved in their establishment, farmers began to establish hedgerows in numbers of fields that far exceeded what the original intentions of the trials had been. From an intended twelve test plots with twelve farmers, by early 1905, the planting of Ipil-Ipil hedgerows had spread within the community to over 40 plots distributed among 24 farmers and covering an area of more than four hectares.

Scarcity of seed was a major constraint to the more rapid spread of the hedgerow technology. Farmers begged, bought, and bartered Ipil-Ipil seed, but were unable to satisfy the demand. Neither was the project able to provide sufficient seed to enable all farmers who wanted to plant to do so. Despite the widespread interest in planting Ipil-Ipil hedgerows, a few farmers were not interested in the seed because of prior experience with local varieties of Ipil-Ipil and concern that heavy pruning would result in its dieback. Thus, although there was widespread interest in the technology that could not all be satisfied, it was not unanimous.

Following the establishment of the initial twelve trial plots with hedgerows, visitors to Barangbang were told that the site work did not belong to the site staff, who merely assisted the farmers in the work, but belonged in fact to the farmers. Since many visitors were clearly advocates of participatory approaches to development, the forthrightness of these comments might have been questioned. However, the independent farmer research carried out in some of the trial plots as well as in their own plots lends credence to the statement.

To successfully improve soil fertility over time, periodic pruning of the hedgerows and incorporation of the leaf matter into the soil is required. But farmers had an alternative use for the leaf matter. They harvested and dried the leaves, and sold the leaf meal in the local market. It was destined for Cebu, the second largest city in the Philippines, where it was palletized into commercial livestock and poultry feed. Even before the introduction of Ipil-Ipil hedgerows, however, household level collection and sale of Ipil-Ipil leaf meal was a major source of cash income. Thus one immediate motive for the rapid establishment of additional Ipil-Ipil hedgerows was to increase the area of Ipil-Ipil that could be harvested for sale.

Initially, the project's management guidelines for the trials did not permit the harvesting of the leaf matter for sale but required instead that it be returned to the soil. With the introduction of the new faster growing, giant variety of Ipil-Ipil, farmers began to experiment with pruning practices for the cultivation of Ipil-Ipil for sale. They were also concerned with the pruning instructions given by the project, believing that the resultant heavy and regular pruning might lead to dieback of the young trees. As farmers

developed a strong appreciation for the new faster growing variety of Ipil-Ipil, the scarcity of seeds also became a problem. The continued harvesting of leaf matter does not allow need pod formation. When farmers could not get enough seed from the project or from other individuals in the area, they began to experiment with leaving individual trees or plots unpruned for seed production. This required a trade-off in increased shaded areas under which planted cereal or root crops would have to compete for sunlight with the shrubbery towering overhead.

During the period that the hedgerows were being established, the testing of the three separate cropping patterns grown between the hedgerows continued. After the first year of trials, farmers in discussion with site staff began to change and combine the cropping pattern work. One pattern was eliminated outright, and changes were made in the remaining two. Eventually, farmers began to experiment on their own with what they felt were appropriate crops for shaded areas within the contours, introducing varieties of upland taro which were felt to be shade resistant. As the popularity of the hedgerows grew and farmers refined the techniques for establishing and managing them, institutional pressures developed to try to extend the technology to other areas in and outside the project.

Building on the successful efforts of Cebu farmers in communicating the technology to Barangbang farmers, it was proposed and eagerly accepted by the farmers that they provide training in Barangbang in hedgerow technology to other farmers. The initial efforts with farmer groups from other areas of the project went well as training exercises, with large turnouts of Barangbang farmers to train guest farmers in a one-to-one ratio. Diffusion of the technology within other sites of the project was not accomplished, however, primarily because of differences in forms of prevailing land tenure (i.e., share tenancy) and in significantly higher soil acidity in other sites stunting the growth of Ipil-Ipil.

However, Ministry of Agriculture attempts to replicate the program in municipalities surrounding Villaba have had greater success because of similarity of soil type and topography and similar situations with land reform beneficiaries. Using the Ipil-Ipil hedgerow technology that Barangbang farmers refined after bring it from Cebu and utilizing the same training program of farmers training farmers with the first trainers being trained themselves in Barangbang, 90 additional farmers were trained and have established plots with Ipii-Ipil hedgerows. As in the Villaba case, seed scarcity continues to restrict the rate of spread.

In the last year, aspects of the technology have come under severe pressure as heavy Psyllid (a whitish colored leaf hopper) infestations the length of the Philippines have decimated both traditional and improved stands of Leucaena. Serious questions must also be raised about the effect of continued pruning in the hedgerows as fungal infections appear to be producing significant rates of hedgerow dieback. Despite the problems that appear to be developing with the sole reliance on Ipil-Ipil for hedgerow material, farmers are continuing to refine the technology and work with Villaba site staff to develop possible solutions to the above problems.

Farmer participation from the initial development of the hedgerows until the present has changed as the formation of formal associations of farmer co-operators and the use of incentives to maintain and reward farmer co-operators has increased. This has in turn divided the community between those directly associated with the project and those without direct association. Although this recent division grew out of site staff efforts to provide at least minimal aid to some of the community members when they could

not help everyone following a devastating typhoon, it has affected the extent of farmer involvement. Nevertheless there remains a participatory base that is still active and taking the lead in the research process. In the final analysis, the overall value of the Barangbang experience lies less in the long term viability of the technology about which there is some question, and more in the nature of the role played by the farmers of Barangbang in the refinement and spread of the hedgerow technology.

Jaro Improved-Fallow Research

Unlike the work in Viliaba which developed out of the initial efforts of the project to identify and initiate research activities, the legume-enriched fallow research in Jaro followed from the previous two years of cropping pattern trials and the problems they encountered. It had the benefit, then, of previous information about the upland production system learned during the first set of trials and could presumably build upon the relationships already established with farmers in the area.

Daro, the barangay of Jaro in which the majority of research activities of the site were concentrated during the conduct of the improved fallow research, presents a very different impression from that of Barangbang to the first-time observer. Easily accessible by all-weather road from Jaro, as one leaves the paved streets and two story houses in what is a distinctly urban setting, he is gradually engulfed in the dense stands of coconut trees and underbrush of the flat, gently rolling countryside. Occasionally open areas under sparse stands of coconuts are found cropped with corn, upland rice, sweet potato, and cassava, crops struggling to survive in the heavy shade and highly acidic soils. Carabao grazing in small pasture areas under the coconut or hauling sleds filled with coconuts dot the landscape.

As one moves away from the road on foot along slippery tracks worn deep from the steady passage of carabao-drawn sleds, the terrain climbs gradually towards the mountains in the background. Deep gorges cut through newer and less dense stands of coconut than those found along the road. Underneath vast expanses of "Cogon" (Imperata cylindrica) and other grasses grow.

Small clusters of farm houses are found occasionally, but many more are scattered throughout the coconut and open areas, barely visible to each other. The majority of farmers are share tenants or part tenant, part owner operators (see appendix 1). The farm units, which include distant lowland rice fields as well as upland coconut areas vary greatly, ranging from less than one hectare in size (18% of the farm population) to more than 5 hectares (18% of farm households).

Farmer involvement in the site research activities during the first several years preceding the legume-enriched fallow research had been through their participation in researcher-managed and frequently –implemented cropping pattern trials, in which farmers provided land for trials, did land preparation, and provided comments and evaluation of the results when asked. Selected farmers were also recipients of numerous goats and carabaos dispersed throughout the area, as well as several large demonstration plots of multi-storied intercrops of pineapple and cacao grown under the coconut. Farmer co-operators from the several barangay in which the project worked also attended regular farmer meetings on a monthly basis. The results of the cropping pattern trials had demonstrated that although several components of the cropping patterns, such as an introduced peanut variety, were of interest to farmers, the patterns themselves conflicted with the production system. The greatest conflict between the introduced cropping

patterns and the local production system centered around general patterns of land use. While the introduced patterns assumed a sedentary and constant cropping of the land, farmers were in fact leaving the land to fallow after several croppings. In some cases, farmers were involved in relatively long-term systems of slash and burn cultivation, with fallow periods lasting from 5-15 years after the land was last cultivated. While in fallow, the land would be used as pasture until it became too overgrown for grazing.

Because of repeated burnings, the plant succession of grasses such as Imperata cylndrica followed by larger bushes and shrubs would be interrupted. This resulted in some fallow lands remaining in Imperata for periods of from ten to fifteen years. At that point, farmers with a great deal of effort and additional labor would clear and recultivate the land.

In reviewing the results of the previous trials and the increased awareness of the problems farmers encountered in fallowing and subsequently recultivating the land, four fallow-associated problems were identified: need for restoration of soil fertility, control of "cogon" in fallow areas, high labor costs associated with land clearing after fallowing, and a need for improved pastures. The introduction of various vining forage legumes was proposed as a possible solution to all four problems.

Following the decision to proceed with forage legumes, a series of informal, highly focused diagnostic and design surveys were conducted in Daro to better identify the fallow practices and periods. At the same time a series of informal conversations and formal meetings with farmers were held to discuss the use of forage legumes under coconut. Staff from the Philippine Coconut Authority and local farmers from neighboring barangays were brought in for the meetings in the research staff's office to discuss with Daro farmers the advantages of growing forage legumes under coconut as a fallow crop. The practice was known to be used by a few farmers in neighboring communities, but had never been adopted in Daro.

During the meetings, concern that grazing carabao and pigs might pose a problem to the establishment of the legumes was raised with the farmers. Despite the fact the livestock damage had been a problem in the earlier trials, and is a constant source of conflict in the area, farmers assured site staff that they could control the grazing problem.

Agreement was reached with farmers to try several forage legumes (Centrosema pubescens, locally known as "karakamote"; Colopogonium muconoides, known as "anipay"; and Pueria phaseoloides, or "kudzu") established in monoculture or in mixture. As part of a project experiment in "rolling trial design" that would permit the research to be more responsive to farmers, plot size could vary from 100-500 m2 for the test plot. The control plot could be 25% of the test plot's total area. Farmers were allowed to select the legumes to be established, and whether they would be relayed into a standing crop in a field ready to be fallowed, or planted into a plowed field already in fallow. Although labor shortages had been identified earlier as a major constraint to farm activities, and plowing of fallow lands the most laborious of all farm work, the farmers agreed to provide the labor for thoroughly plowing the fields as needed. They also consented to collect cuttings of "kudzu" for Pueria establishment, and to plant the other legume seeds provided if selected as a treatment.

During the design survey when plots were identified for the trials, farmers selected legumes to be established. Of twenty one farmers first identified who wished to cooperate, 11 indicated a preference for Pueria, 7 indicated a preference for a Pueria and Centrosema mixture, and 3 elected to have pure Centrosema. Problems both with the trial establishment and

subsequently with farmer cooperation began to appear shortly after the first trials were set out in August of 1985. Field notes indicate that during the planting of the first trial plot, which was established jointly by site staff and farmer using hoes to relay Centrosema into a field of corn, a neighboring farmer had already begun experimenting with the planting of Pueria cuttings in two rows to see how well they grew. These cuttings dried out and failed to establish themselves, as did all other cuttings planted during the next several months.

The failure to establish the Pueria cuttings was further compounded by the low germination rate and slow growth rate of the first fields planted to Centrosema seed. Nevertheless, the poor establishment of the Pueria resulted in a project decision to plant pure stands of Centrosema and wait until a later time to continue with the Pueria. This meant that if the trials were to continue, farmers who had indicated an earlier preference for Pueria would have to plant Centrosema.

Despite the initial indication of interest in setting up the forage legume trial, the farmers busy schedule of farm activities made it extremely difficult for them to prepare trial plots for planting. Only with repeated visits over the next four months and with some urging was it possible to obtain 13 of the originally 21 promised plots in various degrees of preparation. In order to hasten the establishment of the plots, it became necessary for site staff to plant the trials themselves, often in complete absence of the farmer. Of the thirteen trial plots eventually set out in what had been intended to be farmer-managed and farmer-implemented plots, 6 plots had been planted solely by research staff, 4 planted by research staff assisted by the farmer or a family member, and only 3 planted by the farmer him- or herself.

Although the Centrosema recovered over time from the initial stunted growth rate following germination, its failure to grow aggressively resulted in farmers labeling it "slow". As one woman remarked, if the growth of Centrosema was that slow, it would take years before it could help in restoring soil fertility. Another farmer reported being mocked by other farmers passing by and commenting that only a fool would plant a crop he could not harvest.

The generally poor performance of the legumes was further exacerbated by extensive and repeated damage to several plots by grazing livestock. It was subsequently discovered that at least one plot had been placed in an area generally used for grazing carabao when farmers would bring coconuts out of the hills. In other cases it was the animals of the farmer himself. In one instance, the farmer indicated that the repeated grazing of the plot was done by his neighbor's carabao, but that he did not want to make trouble by telling him that his carabao was forbidden to graze in the trial area.

Six months after the establishment of the first trial some farmers were abandoning trial plots or had plowed parts of them under and planted them to food crops. Nevertheless, interest in legumes as part of an improved fallow strategy in Daro survives. Six farmers have returned to their original choice of using "Kudzu" cuttings for establishment. They are experimenting on a much more modest scale requiring no land preparation and only two short rows of cuttings. Even here, however, research staff continues to make significant contributions in the collection and planting of cuttings. It is recognized now that even this level of experimentation is extremely time consuming, but it is a scale and form of experimentation with which farmers are comfortable. Several other farmers are experimenting with broadcasting Pueria seed into the fallowed areas and then burning or chopping the vegetative cover. No one will

now consider preparing the land for legumes: it is inordinately costly and the experience with the establishment of the legumes was not impressive.

Farmer Participation: Some Tentative Conclusions

The complexity of the case studies and the similarity of the processes followed in each for involving the farmer makes it impossible to draw other than tentative conclusions about what contributed to the success or lack thereof of fostering substantive farmer participation. In retrospect one can evaluate the two research programs and come to conclusions about which was more successful in engendering farmer involvement, but it would have been a difficult case to make objectively in the initial periods of either research process. Neither do we feel that any single factor is capable of explaining the events that occurred or the final results.

The heavy use of group meetings with farmers to design and ratify research agendas is particularly vulnerable to eliciting biased or erroneous responses (Vierich, 1983). Too often we allow the situation to become structured in a fashion that puts the farmers at a disadvantage socially in any interchange with researchers. This can be done by arranging meetings in which researchers become the hosts and leaders by having farmers come to field offices rather than meeting with them in their own meeting places. The injudicious presence of several vehicles, especially with government license plates, can also create an artificial situation in which the social distance between researchers and farmers is emphasized by the presence of the symbols and accoutrements of wealth, power, and status.

Barangbang, Viliaba benefited from the isolation that made it impossible for vehicles to enter. Similarly, the lack of project offices in the "sitio" during the time that research agendas were being set and trials established made researchers and visitors appreciate that they were guests of the farmers and not vice-versa. Equally important, because the farmers were meeting in their own familiar settings, supported by families and neighbors, they did not feel the need to demonstrate the same degree of reserve that would have been expected of them had they been meeting in project offices. The reduced social distance facilitated a more equitable interchange of ideas and information, and resulted in a genuine and frank expression of interest in the research.

In contrast, farmers in Daro, Jaro met with project staff in the project office always at the bidding of the project. The more important the meeting, the more project vehicles , drivers, ad staff would be present, reinforcing the presence of the site staff. The social distance would be unavoidably stressed rather than understated. The tendency for farmers to provide the socially acceptable response, or one that their image of researchers demanded, makes it difficult to elicit non-standard responses. In the context of the Philippines, Hollnsteiner describes the situation like this:

> "The researcher is often received into rural households with a hospitality that is both overwhelming and traditional....For integral to the Filipino concept of hospitality is the desire to please, and while this attitude is gratifying for the average visitor, it can be a source of worry for the researcher....he (the villager) feels obliged to demonstrate the tradition of hospitality. Accordingly, the host and his family tend to give the researcher what they consider the expected answer rather than

> one which represents the actual situation. This is not viewed as deliberate lying or even as an attempt to conceal certain aspects of barrio behavior; it is accepted as part of the norm applicable to the entertainment of likeable strangers (1963, pp. 198-199).

This tendency is exacerbated where group leaders take a dominant role and the remaining participants are expected to be passive but supportive of the leadership (Castillo, ibid). In small, homogeneous groups such as that of Barangbang, Villaba minority interests or dissenting positions are less likely to exist. In Daro, Jaro, however, the farmer population is fairly heterogeneous, but neither the culture nor the situation facilitates the expression of dissenting or minority viewpoints once the group leaders have expressed a position. Thus public assurances by a few that grazing livestock would not be a problem and that farmers were willing and able to provide the labor for tilling the fields for legume establishment could not be publicly disavowed by the rest. Some farmers could provide labor for tilling the plots. They were also able to regulate the use of the trial areas as pasture for grazing animals. Other farmers who did not enjoy the same degree of wealth, power and social position could not publically express inability to provide labor or control the usufruct rights of their more powerful neighbors to use what appeared to be prime pasture lands. To do so would have brought shame or "hiya" upon the demurring farmer. As a consequence, the public position taken by the group reflected a level of commitment that many were not capable of fulfilling. The more popular course of action was passive and nominal compliance when called upon to fulfill the commitment.

Although both technologies were relatively complex, they differed in the extent that they were understood by the farmers and in the degree to which they were adapted to the setting. The Leucaena had been tested by both researchers and farmers under conditions similar to those of Barangbang. Furthermore, Barangbang farmers had the advantage of having seen and talked with farmers before implementing the hedgerows. They were also relatively sure of reaping short term gains from the sale of the leaf meal.

In contrast, Daro farmers were confronted with verifying technology that had not been extensively tested under conditions similar to their own. Neither locally viable procedures for establishment nor rates of growth had been worked out ahead of time. Thus, initial failures in the establishment of Pueria and slow growth rate of Centrosema could only serve to fuel any hesitancy or doubt on the part of farmers about their active participation.

Farmer puzzlement at the slow growth of centrosema and their perceptions of the speed with which it could restore fertility also suggests that initially they held much higher expectations of what the legumes would accomplish over time than was possible. Inadequate knowledge of the technology's performance in the local conditions was compounded by a poorly communicated sense of potential short and long term benefits. The consequences for Daro farmers were the assumption of fairly high risks with very little return.

Finally, despite the flexibility of the Daro research design, pressures to set trials out in a timely fashion rather than wait for the farmers to accomplish them resulted in their transfer from the farmers to the researchers. Notwithstanding the best of intentions in trying to establish farmer-managed and implemented trials, once difficulties were encountered we the researchers moved in to solve them, and in so doing, reassumed management in place of the farmer.

The reverse occurred in Barangbang. Farmer enthusiasm resulted in their taking control of the trials. In allowing the trials to be taken over, the researchers sacrificed much of the methodological rigor that we researchers strive for, but gained in return levels of farmer involvement exceeding all expectations.

By and large, the reasons underlying the differences in effectiveness of farmer participation between the sites of Barangbang and Daro have been identified in other projects as well. Smaller and more homogeneous groups are more effectively involved in participatory approaches than are larger and more heterogeneous groups. The presence of diverse and competing social strata in farm communities must be recognized and addressed accordingly. The use of public forums is likely to be relatively ineffective in creating meaningful participation cutting across social divisions in such cases. It is also helpful to be familiar with the technology tested. In the face of uncertain or unviable technology, large and costly trials are less conducive to active farmer involvement. Given high risks, small and simple trials are more acceptable to farmers. The corollary also holds: a high probability of realizing significant, short-term benefits is motivation for farmer participation.

Finally, once we as researchers chose to foster farmer participation in a decision making mode in agricultural research, our commitment must not falter. Farmers must be given the time to do things as they see fit. If we try to hurry them in our haste to generate results, we undercut the very foundation on which farmer participation is built.

Appendix 1

Table 1. Distribution of Farm Units by Farms Size for Six FSDP-EV Sites

	Gandara	Basey	Jaro	Villaba	Matalom	Bontoc
≤1.0 ha.	45%	30%	18%	52%	36%	35%
>1.0 ha. & ≤3.0 ha.	38%	40%	42%	43%	42%	40%
>3.0 ha. & ≤5.0 ha.	7%	20%	22%	5%	15%	11%
>5.0 ha.	10%	10%	18%	0%	7%	14%
	100%	100%	100%	100%	100%	100%

Table 2. Distribution of Farm Units by Land tenure Classification For Six FSDP-EV Sites.

	Gandara	Basey	Jaro	Villaba	Matalom	Bontoc
Land-lord	0%	1%	2%	0%	3%	10%
Owner-Op.	53%	43%	18%	7%	36%	26%
Amort. Owner	17%	3%	0%	75%	0%	0%
Part Own/Op.	22%	24%	33%	7%	32%	19%
Tenant	8%	29%	57%	11%	29%	45%
	100%	100%	100%	100%	100%	100%

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Modes of Farmer Participation in FSR/E

by

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Farmer participation in the philosophy and dynamics of farming systems research and extension is both central and vital to that agricultural development process. Attaining the degree of participation which makes a strategy truly farming systems research in nature, and not something else, is a time consuming task. However, accomplishments in this arena can be most rewarding. Washington State University faculty members on assignments in Lesotho during a seven year intervention have identified several ways in which farmers achieve maximum participation.

Farmers as Collaborators

Since "farming systems" consist of a variety of activities and variables which contribute to the livelihood of farm families, these components must be carefully studied in order to understand the systems. Such studies must be done in a manner such that farmers themselves can explain how and why they do what they do and describe problems or constraints as they perceive them. On-farm research programs are then designed, with farmers as collaborators, to discuss problems and relax constraints. Obviously, national colleagues play key roles in this process in order to facilitate communication between farmers and expatriate researchers. In Lesotho, six key farmers were identified and engaged as full collaborators in the testing of enterprise and activity mixes in which a number of new practices and products were introduced over time into the farming systems of that country. Among those were such innovations as routine use of fertilizers, fodder production, supplemental feeding of animals, use of improved breeding stock, and acquisition of better ox-drawn machinery.

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Farmers as Cooperators

Beyond the selected few farmers who became collaborators as described above, some 80 others were engaged as cooperators. The cooperators volunteered land, labor and equipment in order that field trials of single products or practices might be jointly carried out under real farm conditions. Again, maximum incorporation of traditional farm wisdom was sought. At the same time, field researchers were careful to explain the purpose and experimental nature of the trials program. It was fully explained that certain activities might be successful and others not. It is perhaps significant that so many Basotho farmers were willing to participate in new and exciting field trials. Among the activities that formed the basis for this type of participation were work with improved maize and sorghum varieties, commercial fertilizers and pesticides, fodder production, innovative ox-drawn machinery, improved vegetable crops and irrigation systems.

Farmers as Learners

Farmer contact groups in the form of village agricultural committees were early organized as a principal audience for extension education programs. Over time some 225 farmers participated in such committee work and became fully committed to instruction and demonstration work by FSR/E personnel. The content of the extension and demonstrations programs derived largely from on-farm research and consisted in agronomy, horticulture, plant protection, farm machinery, animal and range management. After four years of such instruction, perceived KASA* change (Bennett 1977) was documented (Youmans, et al., 1985/86) using the reflective appraisal of programs (RAP) evaluative procedure (Bennett 1982). That farmers learned, gained skills and developed changed attitudes and aspirations toward agriculture is illustrated in Table 1.

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* KASA means knowledge, attitudes, skills, and aspirations.

Table 1. Total changes in knowledge, attitude, skills, aspirations, and practice change by 54 respondents in agronomy, horticulture, plant protection, farm machinery, animal and range management, as a result of Extension education programs, 1979-84, Lesotho, 1985.

		Number of respondents					Total Resp	Percentages				
		Z	0	3	2	1		Z	0	3	2	1
Total	Know	2	0	46	6	0	54	4	0	85	11	0
Agr	Att	2	0	46	6	0	54	4	0	85	11	0
	Skill	2	0	40	12	0	54	4	0	74	22	0
	Asp	2	0	48	4	0	54	4	0	89	7	0
	Pr/Ch	2	6	33	10	3	54	4	11	6	19	6
Total	Know	1	0	48	5	0	54	2	0	89	9	0
Hort	Att	1	0	50	3	0	54	2	0	93	6	0
	Skill	2	0	39	13	0	54	4	0	72	24	0
	Asp	1	0	50	3	0	54	2	0	93	6	0
	Pr/Ch	1	9	30	11	3	54	2	17	56	20	6
Total	Know	2	0	43	7	2	54	4	0	80	13	4
Pl/Prot	Att	1	0	46	6	1	54	2	0	85	11	2
	Skill	2		24	9	18	54	4	2	44	17	33
	Asp	1		41	7	3	54	2	4	76	13	6
	Pr/Ch	1	17	13	13	10	54	2	3	24	24	19
Total	Know	4		41	7	1	54	7	2	76	13	2
	Att	2		44	6	1	54	4	2	8	11	2
	Skill	4	0	23	13	14	54	7	0	43	24	26
	Asp	2		46	4	1	54	4	2	85	7	2
	Pr/Ch	2	11	13	20	8	54	4	20	24	37	15
Total	Know	3	0	44	7	0	54	6	0	81	13	0
Ani/Mgt	Att	2	0	46	6	0	54	4	0	85	11	0
	Skill	3	0	26	17	8	54	6	0	48	31	15
	Asp	2	1	44	6	1	54	4	2	81	11	2
	Pr/Ch	2	31	2	10	9	54	4	57	4	19	17

Z - Other
0 - Not at all
3 - To a great extent
2 -= To a fair extent
1 - To a slight exten

Farmers as Adopters

In agriculture, knowledge and skills are only meaningful as they are put to good use and result in improved livelihood for farm families. In the Lesotho experience, farmers not only reported significant adoption rates of agricultural innovations, as seen in the practice change lines of Table 1, but also participated fully in the fruits of those efforts as illustrated in Table 2. Such benefits as better meals for families, food conservation, higher crop yields, better condition of animals, and improved access to inputs are prominent among those outcomes.

Farmers as Teachers

In several farm field days conducted by FSR/E personnel, farmers who had gained knowledge, skills, and experience from the above participative modes were called on to share information with other farmers. The performance of farmers as teachers in the Lesotho context is widely acclaimed. Their earnestness, commitment, and accuracy of information was notable. Furthermore, each member of farmer contact groups became a link in a voluntary horizontal innovations diffusion network. In research concluded in 1986, (Youmans et al.) in which three diffusion modes were studied, it was found that members had become effective teachers of other farmers, demonstrating a combined mean multiplier effect of 8.8 other persons reached by each member. These data can be seen in Table 3.

Farmers as Evaluators

In all phases of FSR/E work in Lesotho, active feedback and other participative evaluation by farmers was sought. First of all, the RAP methodology was used to conduct an extensive evaluation of extension program results. As has been mentioned, this methodology relies on perceived changes by farmers themselves as the principal criteria of program effectiveness. Farmers were likewise asked to describe practice changes associated with FSR/E programs, as well as to

Table 2. End results(real benefits) to members of farmer contact groups of Extension education programs, Lesotho, 1985.

AA	BB	CC	DD	EE	FF	GG	HH	11	JJ	KK	LL	MM	NN	00
39	43	15	39	67	80	43	65	50	50	0	17	3	0	0
57	52	81	56	31	19	39	31	37	44	93	44	9	0	0
0	0	2	4	0	0	11	2	7	2	0	33	15	0	0
4	6	2	2	2	2	7	2	6	4	7	6	39	100	100
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

0 = Yes
1 *=No
2 = Not applicable
3 = No response

Legend to End Results Table

AA = More income from farming
BB = More trading with neighbors
CC = Acquisition of more property
DD = Acquisition of better animals
EE = Stored and/or preserved food
FF = Better meals for family
GG = Better education for children
HH = Higher crop yields
II = Better condition of animals
JJ * Able to purchase improved inputs
KK = Able to secure credit/loans
LL = Improved farm records
MM = Better markets
NN = Other
00 = No significant benefits

Table 3. Diffusion effectiveness of individual respondents, Lesotho, 1985.

Quest Bio data

No.	Age	Sex	Area	Yrs/frm	Educ (Std)	Mig/RSA	Told	Shoved	Observed
1	42			15	5	1	35	6	10
2	48			37	2	1	16	6	4
3	62			14	7	6	8	3	10
4	36			6	6	0	10	5	6
5	47			24	6	1	20	0	5
6	42			11	5	1	30	10	3
7	59			25	1	0	15	2	4
8	42				1	3	15	2	8
9	30			5	6	2	10	5	0
10	71			30	1	0	30	20	5
11	50			20	6	3	5	1	2
12	50			20	3	1	25	15	5
13	55			15		5	30	3	5
14	31			5	4	1	10	4	4
15	43			10	5	1	30	11	10
16	50			20	5	1	35	20	15
17	45			5	3	1	40	7	20
18	40			13	3	1	8	3	0
19	32	Female	Siloe	4	4	3	6	1	0
20	27			7	7	2	2	3	1
21	40			12	4	0	4	3	2
22	55			3	6	2	2	3	2
23	28			2	7	1	15	1	1
24	48			14	3	1	10	5	8
25	48			25	1	2	25	3	2
26	69			4	2	0	0	0	0
27	52			10	2	1	10	6	6
28	39			0	4	4	0	0	0
29	56			31	5	1	0	0	0
30	34			6	3	8	25	0	5
31	42			12	3	2	2	0	0
32	30			2	7	4	30	11	11
33	35			5	4	1	2	1	1
34	48			5	6	4	20	6	3
35	43			12	7	0	7	7	6
36	21	Female	Molumong	5	7	1	20	4	5
37	45			27	6	0	20	19	4
38	31			3	4	1	10	4	4
39	62			36	4	3	5	2	2
40	24			6	6	6	15	2	0
41	62			36	4	3	5	2	2
42	55	Male	Nyakosoba	39	0	1	25	12	7
43	50			25	0	1	30	20	20
44	50			20	0	2	25	13	20

Table 3. Continued -

Quest No.	Bio data Age	Sex	Area	Yrs/frm	Educ (Std)	Mig/RSA	Told	Shoved	Observed
45	51	Male	Molumong	20	2	0	10	0	5
46	59			12	1	2	50	3	5
47	65			35	0	1	10	0	0
48	49	Male	Siloe	14	0	0	15	8	8
49	39			3	5	0	2	2	3
50	64			46	5	4	4	1	1
31	48			4	1	3	25	20	4
52	47			12	3	0	30	25	4
53	70			20	1	2	5	3	3
54	58			12	5	1	4	2	1

elucidate constraints to practice change. Further, they reported on perceived benefits and non-benefits. Finally, they were engaged in providing recommendations for the improvement of field programs.

The conclusion can thus be drawn that there is virtually no stage of the FSR/E process in which farmers should not be full and active participants. Likewise, there are at least six participative modes in which farmers may play meaningful roles. The Lesotho experience has been the more enriching by this active farmer contribution to self development.

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Table 1. Herd structure and production parameters of Bunaji cattle under traditional management in two case study areas, Kaduna State, Nigeria

	Kurmin Biri	Location	Abet
Herd Structure			
Average herd size *	48		35
Lactation cows (%)	22		20
Dry cows (%)	10		9
Heifers (%)	24		21
Calves (%)	22		20
Bulls (%)	17		17
Steers (%)	5		13
Production Parameters **			
Cow survival		94	
Calving percentage		49	
Calf survival		72	
Calf weight at 1 year (kg)		98	
Lactation yield (kg)		300	
Productivity index		48	

*Fulani herds also include sheep at a ratio of about 1 sheep to 4 cattle
**Aggregate data

Source: Mani et al., 1986

Table 2. Fulani farm and household sizes in SHZP case study areas of Abet (1982) and Kurmin Biri (1983)

Location	No. of households		Household size: Persons	Household size: Active males 8 years and older	Farm size (ha/household)
Abet	13	mean	9	3	0.67
		sd	5	2	0.33
		range	2-19	1-6	0.23-1.19
Kurmin Biri	12	mean	12	4	1.10
		sd	6	2	0.53
		range	3-22	1-7	0.40-2.19

Source: Powell and Taylor-Powell, 1984

development. The SHZP, one of ILCA's five zonal programs, was conceived to employ a multidisciplinary team of scientists. This team was to work directly with local producers in case study areas of representative production systems. To gather data and test interventions with slow producing, late maturing ruminant livestock, a long-term presence in the case study areas was anticipated.

The SHZP of ILCA began operations in mid 1978, before the profusion of FSR manuals and procedures. It was based at Kaduna in the central region of the sub humid zone of Nigeria. This zone roughly corresponds to the area known as the Middle Belt where the annual rainfall is between 1,000-1,500 mm with 180 cropping days. It covers over 40 percent of Nigeria's total land area and contains about 20 percent of its population. It is estimated to have about 4.5 million cattle (Bourn and Milligan, 1983).

Ninety percent of the cattle in Nigeria are in the hands of Fulani pastoralists and maintained under traditional management with communal use of grazing lands. Table 1 gives average herd structures and production parameters for traditionally managed Bunaji cattle from the SHZP survey data. A trend among the Fulani to settle was indicated (van Raay, 1975), so the program focused on Fulani pastoralists under sedentarized conditions. An initial state of the knowledge symposium (ILCA, 1979) identified poor animal nutrition, especially during the dry season, as adversely affecting productivity more than any other factor or combination of factors. Improving ruminant livestock nutrition became and remains the SHZP's research objective.

Agro-industrial by-products were scarce and likely to become too costly to be a long-term solution. Improvement of the communally used range was too problematic and uneconomical. The only alternative appeared to be for livestock keepers to grow their own forages. The problem for the SHZP became the development of appropriate forage production techniques which producers could employ themselves and which would have a significant positive impact on cattle productivity. This meant a three-way focus involving crop-animal interactions, i.e., (1) producing forages, for impact on (2) animal nutrition, and (3) soil fertility. Within this framework, the principal lines of research have included forage agronomy, crop-livestock interactions, cattle productivity, small ruminant production, animal health, ecological monitoring, socio-economics to complement the technical studies.

Two case study areas were identified for intensive study of local production systems (Figure 1). The Kurmin Biri site is within a grazing reserve demarcated by the government for Fulani settlement. As of 1984, there were 32 Fulani households settled year-round inside the 31,000 ha reserve with a cultivation density of about 5%. Abet is a site where Fulani have settled spontaneously amid crop farmers. Population density is much higher at about 70 people/square km and about 25% of the land is cultivated. Fulani have no secure rights to land in Abet and must negotiate with local farmers for land on which to settle and cultivate. Occupying about 10% of the population, some Fulani families have lived in Abet year-round for four generations (Waters-Bayer and Bayer, 1984). The indigenous farming groups keep few livestock, principally goats, chickens, pigs, dogs, ducks. Despite land competitions and possible conflicts due to

damage of crops by cattle, numerous advantages exist for Fulani settling in established farming areas. These include better quality feed resources and socioeconomic linkages with the farming communities. For discussion of the crop-livestock interactions in the SHZP study areas see Powell and Waters- Bayer, 1985; Powell, 1986.

As seen in Table 2, the average cultivated area for these settled Fulani is about 0.87 ha/household. This is about one-third the crop area cultivated by local farmers. The principal crops are sorghum and maize, either sole cropped or in combination, and millet. The objective is subsistence grain production so that animals do not have to be sold to purchase grain.

While considered "settled", these Fulani may periodically move their homesteads within a limited distance. They normally herd their cattle within a few kilometers of their homesteads. Most, however, are prepared to move their homesteads and herds elsewhere if poor grazing, inadequate water, disease, or unpleasant relations with farmers develop. Commonly, they deploy their herds or part of their herds, at various times of the year, to exploit localized grazing resources and to distribute stocking pressure. Transhumant herds also use these areas during the dry season presenting a competition for grazing and water resources.

On-Farm Trials

The SHZP presents a unique example in the practice of FSR: until 1981-1982 it conducted all its research directly with local pastoralists - there was no experiment station. Research institutes in Nigeria had conducted extensive research the results of which the SHZP was expected to apply to local production systems. On-farm trials were initiated within the first year only to reveal that the research station techniques did not work when tried on Fulani farms. Data collection was complicated by numerous factors including (1) reluctance of herd managers to have their animals ear tagged - animals in a herd were paired and tagged to indicate treatment and control; (2) the practice of splitting herds and moving animals at various times of the year; (3) sales, exchanges, and transfers of animals; (4) complex ownership patterns; (5) taboos such as not talking about herd numbers, sale prices, or affixing ownership; (6) interference of producers in experiments by feeding control animals, adding fertilizer to test plots, applying their own ethno science, etc. Individual management variations were great. Feeding and grazing regimes were changed from day-today making precise record keeping impossible.

However, the scientists gained invaluable knowledge from the on-farm trials and became acquainted with the realities of the Fulani production conditions, i.e., interactions and consequences on production decisions due to variations in the onset and duration of the rains, severity of the dry season, and seasonal variations in cattle populations; disease and pest incidence; labor competitions between crop and livestock components; no control over land use, etc. It also became clear that component research was needed to back-up the on-farm trials. The program was allocated land in both case study areas and a herd of some 60 head of cattle. Information gained from the on-farm trials directed the station research.

The on-farm research remained the important tool for learning about producer circumstances, objectives, and problems. There was virtually no literature available on the settled Fulani agropastoral system when the program started its research. Little biological research had been conducted in the Subhumid Zone environment. Surveys administered by the team experienced the common problems of unreliability, untidiness, and lack of local analysis capability. It was the on-farm experiments, rather, and the direct contact with the producers that provided the information for understanding the complexities and interactions within and between the local crop farming and livestock production systems. In the words of one team member, "Only when you get to working on farms with farmers does the real information come out."

Producer Cooperation in LSR

In the FSR literature, considerable attention has been given to the need for farmer participation and to the grouping of farmers into recommendation domains. Less attention has been given to the realities of gaining and maintaining producer cooperation. Perhaps, these latter considerations pose fewer problems in cropping systems research where there are numerous producers within a locale and treatment effects can be observed in one season so that short-term participation is sufficient. For researchers working with mobile and/or hard-to-reach cattle producers, the situation is different. Observed responses are not quickly evident and several years' records are needed on the same animals. In the case of pastoral cattle, the generation interval is five years or more (birth to first calving). Also, while a farmer may give up a few rows of his crop for on-farm trials, few cattle keepers will be willing to turn over their herds or even animals within the herd.

Selecting Cooperators

In on-farm research, the intent is to "select" representative cooperators with whom to conduct experiments, recognizing that no two producers are totally alike. This presumes a pool of producers from which to select cooperators, their acceptance of cooperation once selected, and the ability to identify factors that represent the key groupings.

The SHZP began on-farm trials as soon as possible in order to establish the program's legitimacy and to gain producer cooperation. There was no pool from which to select its research sample. Rather the SHZP was dependent upon those Fulani who came forth and who would permit researcher access to their herds and households. Also, the herds and fields of cooperators had to be within serviceable reach. The research sample, thus, became those Fulani who were willing and able to take the risks of cooperating with the "unknown" research program and whose herds and fields could be reached with a four-wheel drive vehicle. For the early on-farm trials, there were simply not enough Fulani within reach and expressing interest to be selective. Any intent of representative sampling was constrained by the reality of working with Fulani cattle keepers: they had to be accessible, available during management operations; and willing to accept the risk of making changes.

The differences and similarities in the research sample (socioeconomic) and sites (biological) and the Fulani motives for their

cooperation became factors to discover and include in the management and evaluation of the on-farm trials. As the on-farm work progressed, the critical factors influencing production decisions became clearer. Then it was possible to define groupings of cattle keepers for whom more or less the same recommendation would apply. As the program gained legitimacy and expanded into new areas, it became possible to select more representative samples for the on-farm trials. Yet, the long-term nature of data collection on animal performance meant a dependence on the initial group of cooperators for data needs.

Maintaining Producer Cooperation

The SHZP architects knew that sustaining Fulani cooperation would be essential for collecting data and testing interventions. This was one reason for hiring a veterinarian who could provide good will treatments to the herds of participants. Also, initiating feeding trials using agro-industrial by-products early in the research process was a way to help ensure producer cooperation.

A few cooperators terminated their participation due to misunderstandings, unfulfilled expectations, and/or wife's influence. But the continued cooperation of a consistent research sample, some 34 Fulani with over 1,000 head of cattle, was largely the result of a variety of incentives the cooperators gained, e.g., rudimentary veterinary treatments and vaccinations for their cattle; inputs for the on-farm trials such as supplementary feeds and salt licks, fencing, seed, and fertilizer; subsidized fertilizer for personal use; prestige through association with the SHZP; household earnings from employment in record keeping. Granting such benefits served to gain and maintain cooperation in the absence of proved research results. But these benefits also influenced the sample and biased their participation. The cooperators also became aware of the program's need for continuous data and, on occasion, threatened withdrawal in their attempt to gain other benefits. A particular problem exists for livestock research in terms of compensating participants for the risks and inconveniences involved in on-farm research.

The continued cooperation of the collaborators also was due to the good rapport that was established when researchers and producers worked and learned together. Careful explanations were needed of study objectives and methods. Simple experimental designs were used which producers could understand and which the local field staff could supervise. Weekly tours by the Field Program Manager helped to clear-up misunderstandings and foster good relations. The social scientists, in particular, kept tabs on the pulse of the community and solicited opinions and comments. Good relations were needed not only with the research sample but also with the non-participating local inhabitants in the field sites, particularly, when the target group was not landowning as in the case of the Fulani. The SHZP experience indicates that LSR practitioners should be careful not to underestimate the time and resources needed to establish and maintain producer interest and cooperation over time.

THE FODDER BANK TECHNOLOGY

Over the years, on-farm and component research have been conducted on various cereal-forage crop interactions within both the Fulani and arable farming systems (for details see Mohamed-Saleem and Kaufmann, 1983;

Mohamed-Saleem, 1986a). Fulani farms were too small to provide sufficient forage even if forages were incorporated in the cropping cycle. In the absence of any benefit, crop farmers would not grow forages for the cattle owning Fulani. The other land area available for changing the forage situation was non-arable or marginal land.

Designing the Technology

In the effort to use marginal land for forage production, the fodder bank technology evolved. A fodder bank is a concentrated unit of a forage legume which a pastoralist can establish and maintain as a supplement to natural grazing. It was conceived during an early trial of under sowing stylo (*Stylosanthes* spp.) into a sorghum crop: the Fulani cooperator moved his crop area to protect the stylo when it re-emerged in the subsequent wet season. Research estimates indicated that a 4 ha. area could provide sufficient supplemental forage for the 15-20 productive cows (in-calf and lactating females) in the average sized herd for the 180 day dry season (Milligan and Kaufmann, 1979). The fodder bank was to provide supplementary protein during the critical period of the dry season to the class of stock which would respond most profitably. Five years or more of a productive fodder bank were deemed necessary for it to be financially viable. The problem was to design an appropriate technology considering that the Fulani had insecure land rights, limited labor and capital, and no experience with draught power or mechanization.

Initial trials to establish stylo through broadcasting on fallow and bush land failed: seeds washed away and grasses competed excessively with stylo seedlings; what did grow was grazed by sheep, goats, neighbors' and nomadic cattle (Kaufmann, 1981). Despite costs, fencing had to be tried with the local Fulani. Social science studies determined the process for gaining approval for pastoralists to fence and monitored the ramifications. To capitalize on the producer's central asset, the fodder bank technology was designed to depend upon cattle, not human labor or machinery. In this crop-animal interaction, cattle trampled the seedbed, added the manure fertilizer, and controlled the weed competition during the normal grazing and confinement (overnight resting) routines.

Testing the Fodder Bank

The first 4 fodder banks established in 1980 and 1981 were researcher-managed and researcher-implemented. Over the years, producer participation in the trials has gradually increased both in terms of management and investment costs. By 1985, 66 fodder banks had been established in 8 states in Northern Nigeria. Figure 2 shows the number of fodder banks in the Subhumid Zone at the various levels of management. Extension into areas outside the SHZF case study sites has been done by the National Livestock Projects Department (NLPD) in close collaboration with the SHZP. The cooperation of the NLPD and State governments provided the opportunity to check the potential of the technology across a wider range of conditions. The NLPD provides credit to livestock keepers for financing the fencing, seed, and fertilizer which it makes available. Activities in the establishment and management of the fodder bank include (1) fencing the area; (2) preparing the seedbed including necessary land clearing; (3) firebreak establishment; (4) scarifying and broadcasting seeds mixed with

super phosphate fertilizer; (5) controlling early season grass growth through controlled grazing; (6) deferring grazing until the dry season; (7) controlling grazing during the dry season. Age and productivity of fodder banks being monitored as of 1984/85 are given in Figure 3. For more detail on the establishment and productivity of fodder banks see Mohamed-Saleem, 1986b.

Unforeseen circumstances arose as the trials continued, the number of fodder bank tests increased, and producers were given greater management decision-making. Erratic rainfall patterns resulted in differing levels of legume establishment. The timeliness of stylo sowing emerged as a critical factor in determining herbage yield in the first year. Fires in the dry season partially or totally damaged various fodder banks. Of the three forage cultivars released by the Nigerian Animal Production Research Institute (NAPRI), one, in particular, fell susceptible in the subhumid zone environment to the fungal disease, anthracnose. A second appears to be increasingly susceptible. The SHZP had to begin variety testing to evaluate alternative legumes. The resources, reactions, and management inputs among the fodder bank testers were extremely varied. In effect, each fodder bank became a separate case.

What the Fulani testers and test sites brought to the research trials became variables to uncover and include in the analyses. The socioeconomic diversity of the testers can be seen in Table 3. When the research team made certain recommendations, the Fulani collaborators did or did not follow this advice. In many cases, they applied their own experimentation and indigenous knowledge. While fascinating to the social scientists, the trial variations were frustrating to the technical scientists who were dependent upon these experiments for statistically viable data. Replications were severely limited by the shortage of animals and units of land under the scientists' control. Many of the early participants were motivated by what they thought participation in the fodder bank program would bring - access to supplies and services, status and prestige in being associated with the government. When cooperation in the trials was not self-initiated or was stimulated by one of these ulterior motives, the fodder bank testers, in large part, were unwilling to shoulder the establishment and maintenance tasks and were reluctant to repay their loans. In large part, these fodder bank test sites were lost as data sources.

In 1983 an evaluation of producer behavior was initiated. This was conducted by one of the part-time social scientist's who largely used participant observation techniques. A variety of reactions and adaptations to the fodder bank technology emerged which had not been indicated during the early diagnostic work or researcher-managed trials. As a result, research recommendations were modified and/or new lines of research were undertaken. The type of input Fulani participants had on the SHZP research process can be seen in the following examples.

1. Early investigations indicated that the Fulani would be able to negotiate for land on which to establish fodder banks. But as the number of fodder banks expanded, this was not necessarily the case. The ability of Fulani to acquire land for fodder banks depended upon multiple factors including localized variations in the land tenure system, fragmentation of

holdings, opportunity costs of the land, individual farmer-Fulani relations, and level of researcher involvement in the trials, i.e., landowners were willing to grant land when the fodder banks were viewed as government initiated but not when seen as Fulani undertakings.

Also, Fulani interest and responses changed when the costs of fodder bank establishment were actually transferred to them. Differing reasons for settling and types of settlement (permanent vs. temporary) influenced Fulani decisions about land investments. Necessary preconditions for having a fodder bank included (1) secure land which farmers would not reclaim or encroach upon; (2) land which was close to or favorable for the family compound - people, crops and cattle all go together; and (3) the intention of permanent settlement.

Given the problems that insecure land rights placed on forage improvements, fodder bank tests were expanded into other areas where pastoralists either already had or could more easily obtain land. Also, areas were identified where local farmer landowners owned and kept cattle. They could establish fodder banks on their own land for their own cattle. A flexible recommendation regarding the size of the fodder bank was signaled to be congruent with the land available, herd size, producer's resources and intended use of the fodder bank. Increased experimentation was called for to establish the benefit of a legume based pasture to subsequent cropping which would provide an incentive for farmer landowners to loan land to Fulani.

2. Not surprisingly, the perceived costs of the fodder bank in relation to the expected benefit affected producer decision making. As seen in Table 4, establishment costs in 1984 amounted to about US $3000.00 for a 4 ha. fodder bank. Fencing, which had to be sheep-proof, fire and termite resistant, was the major expense (74% of total costs). It, also, was the central benefit in the eyes of the Fulani. Research on live fencing using such species as Leucaena and Glyricidia proved unsuccessful in the subhumid zone environment. Fulani testers experimented with local fencing materials to cut costs. A local Ficus spp. used as live fence posts appeared the most promising.

The central benefit of the fence was that it protected the area from communal grazing. It did not secure land rights which some critics suggested was the Fulani intent. For those Fulani who cultivated crops within the fenced enclosure, the fence protected their crops from animal damage. Fulani attitudes about the benefit of the fodder bank were influenced by such factors as the severity of the dry season nutritional constraint on their herds, the size of the fodder bank in relation to their herd size and production objectives, and the time horizon needed for pasture development.

3. On-farm trials were conducted in succeeding years during the dry and wet seasons using cattle to trample the legume seedbeds during their overnight confinement. This was to capitalize upon the traditional practice whereby cattle are confined at night either tied in pairs at the ankle or enclosed in a brush or lightly strung wire corral. For the dry season trials, it turned out that the manure caused increased grass competition to the legume when the rains began. Also, in some areas,

Fulani were paid for confining their cattle overnight on farmers' cropland in the dry season (about US $8.50 per week for the manure from a herd of 50 cattle excluding the value of settlement rights, Powell and Waters-Bayer, 1985). This obviously took priority over preparing the fodder bank.

The wet season trials gave better but varied results. Fulani reactions were linked to their long experience in using cattle to prepare rice and iburu (Digitaria iburea) seedbeds. Also, they confined cattle overnight on cropland during the early wet season for manuring purposes. Consequently, they had considerable experience with the effectiveness and efficiency of using cattle for trampling and manuring which influenced their attitudes and behavior in preparing the fodder bank. In some cases, herds were too small to adequately trample the intended area and combining herds beyond the existing management unit was untenable. Also, for these Fulani, with a subsistence cropping objective, using cattle to manure cropland took priority over fodder bank preparation. As a result, seedbeds were not properly prepared or seeding was delayed.

The variation in results indicated that additional research was needed to evaluate other establishment methods. Alternative low-cost stylo establishment techniques have been identified which can be used as and when needed. Table 5 shows experimental data on land preparation and seed treatment techniques.

4. Research from Australia indicated that cattle selectively grazed grass over legumes when the grass was young. The research team, therefore, recommended that herds use the fodder banks during the early rainy season to graze the competing weed growth. The Fulani experience, however, was that animals picked up internal parasites from recently manured areas and that cattle refused to graze where the manure smell was strong. More research was undertaken to identify establishment methods which did not involve manuring. Likewise, research was initiated to see if and how selective grazing behavior might be used in the Fulani system to control weed growth.

5. In the initial trials, Fulani seldom followed the team's advice of using the fodder bank during the dry season for only the 20 odd breeding cows in the herd. During the 1984 dry season, 11 fodder banks for which a grazing recommendation was made were closely monitored to see exactly which animals were using the fodder banks. Informal follow-up interviewing was conducted to understand why.

The Fulani did not restrict fodder bank use to the breeding females as intended by the SHZP. They did, however, restrict frequency of use. Based upon personal estimates of forage availability and cattle grazing behavior, they combined fodder bank grazing with their normal patterns of daily herding which utilized a variety of forage and browse species (for details see Bayer, 1986). All the Fulani chose to graze their animals in the fodder banks in the morning and restricted use to 2-3 hours as recommended. Animals could be separated more easily at the time of milking which was done exclusively in the morning. Also, a few hours of morning grazing inside the fodder bank fitted into the dry season grazing management when the long grazing day was split between two shifts of herders.

The research team had envisioned the fodder bank as a protein supplement to increase production of the breeding stock. The Fulani saw the fodder bank as a grazing resource to aid weak animals and to sustain the herd. Fulani indicated that 3-5 animals per herd either died or had to be culled and sold due to the dry season grazing constraint. This situation had not been indicated during the pre-research state of knowledge reviews. Because cattle were kept for a variety of economic and social reasons, the Fulani feeding objective in the dry season was to minimize, or ideally eliminate, animal losses. The profitability of the fodder bank was in having a grazing reserve for use, particularly in the late dry season, to tide animals over until the rains commenced. They practiced a maintenance or survival feeding strategy. This meant being able to sell an animal when desired, i.e., when in good condition, when the sale price was high, when cash was needed, rather than when demanded by external events such as an emergency sale in the late dry season at which time the animal was emaciated and market prices were low. The mean difference in value between a normal sale and such an emergency sale was in the order of US $384.00/animal (Kaufmann and Blench, 1986).

As a result of these reactions, the recommendation for fodder bank use was modified to include animals that would otherwise die or have to be sold prematurely at low prices. Evaluation of the fodder bank technology changed to be based upon producers objectives and viewpoints. It is estimated that fodder bank owners can save at least two forced sales worth $767.00 per year and the total costs of fodder bank development can be redeemed by saving 8 such animals (Kaufmann, unpublished data). In an analysis using a simulation model, saving animals by feeding whole herds gave a higher rate of return on the investment in fodder banks even though the final incremental net revenue was less than on the pre-research model based on selective feeding.

Fulani management, also, indicated that the most economical use of the fodder bank was to restrict grazing until the later part of the dry season. Experimentation was undertaken to fill the void in the research literature regarding pasture supplementation for only part of the day and year. It was the part-time ethnography of producer behavior during the fodder bank trials that ascertained the potential acceptability and profitability of the intervention. This research would support Bernsten et al (1984) in saying that the "intuitive insight" of participating farmers is the critical ingredient for identifying constraints and for evaluating interventions given the limited application of conventional statistical and economic tools in livestock production systems research.

DISCUSSION AND CONCLUSIONS

The participation of producers in agricultural research is to guarantee the acceptability and adoption of new technologies. But implementing participatory research is not easy nor simple. Outstanding issues and problems exist regarding the type of producer participation and the methods for ensuring effective participation during the various stages of on-farm research. This is particularly true for livestock programs which deal with mobile, hard-to-reach, and slow producing cattle. Selection of

collaborators and the need to maintain cooperation over time were found by the SHZP to be particularly troublesome issues.

The SHZP experience clearly shows the dynamic and iterative nature of FSR. On-farm trials were initiated early in the research process. Working with and learning from these cooperators, the trials provided invaluable information, much of which only could be known by doing. Through repeated testing and evaluation with considerable producer input, the team of scientists adjusted and increasingly refined its research. Recommendations evolved as did the identification of well-defined groups of producers for whom the recommendations applied. The Fulani adapted the fodder bank to meet their own needs and resources. In so doing, they added to, modified, and continued the process of technology development.

As found by others, participant's responses and inputs often changed when the trials became totally producer implemented and financed. The real problems and potentials of the technology emerged during the final stage of testing. Based upon Fulani perspectives and assessments, it was at this point that the important information came out in terms of the profitability of the fodder bank, the most economical period of use, different establishment and management options, etc.

If programs are to be truly participatory, then producers must be able to influence agricultural decision making rather than be mere implementers of researchers' trials on their farms. This requires that the research team understand farmer behavior during the on-farm tests. Technical scientists often lack the training or time to closely follow farmers reactions. Herein, lies an important role for social scientists trained in the anthropological method of participant observation: discovering farmers own evaluation criteria and their reasons for adaptations and then successfully communicating these viewpoints to the FSR team and extension personnel. The important contribution that social scientists can make during testing and analysis has been noted by others (Lightfoot, 1984; Tripp, 1985; Rhoades, 1986). Ideally, the monitoring of producer behavior should be a continuous process throughout technology development. In reality, FSR programs generally employ few social scientists and do not necessarily accord them equal status with other disciplines. The experience of the ILCA Subhumid Zone Program confirms that social sciences should be integral to interdisciplinary livestock systems research.

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Table 1. Herd structure and production parameters of Bunaji cattle under traditional management in two case study areas, Kaduna State, Nigeria

	Kurmin Biri	Location	Abet
Herd Structure			
Average herd size *	48		35
Lactation cows (%)	22		20
Dry cows (%)	10		9
Heifers (%)	24		21
Calves (%)	22		20
Bulls (%)	17		17
Steers (%)	5		13
Production Parameters **			
Cow survival		94	
Calving percentage		49	
Calf survival		72	
Calf weight at 1 year (kg)		98	
Lactation yield (kg)		300	
Productivity index		48	

*Fulani herds also include sheep at a ratio of about 1 sheep to 4 cattle
**Aggregate data

Source: Mani et al., 1986

Table 2. Fulani farm and household sizes in SHZP case study areas of Abet (1982) and Kurmin Biri (1983)

Location	No. of households		Household size: Persons	Household size: Active males 8 years and older	Farm size (ha/household)
Abet	13	mean	9	3	0.67
		sd	5	2	0.33
		range	2-19	1-6	0.23-1.19
Kurmin Biri	12	mean	12	4	1.10
		sd	6	2	0.53
		range	3-22	1-7	0.40-2.19

Source: Powell and Taylor-Powell, 1984

Table 3. Socio-economic characteristics of fodder bank testers
(n = 1 8 Fulani)

Characteristic	Average	Range	Responses
Herd size (a)			
no. cattle/hshld	60	30-124	
no. sheep/hshld	9	0-31	
Farm size (b) (ha/hshld)	1.1	.23-2.19	
Household size (a)	14	8-22	
Active males/hshld (a),(c)	5	2-8	
Age of hshld head	48	28-75	
Off-farm income			
yes			9
no			9
Literacy (hshld head)			
Arabic			4
Hausa + Arabic			4
Hausa + English			1
Hausa + Arabic + English			1
None			8

(a) n=17; excludes 1 household with 700 head of cattle and 30 in the household because atypical of sample
(b) n=10 farms measured; all these Fulani farm except 1; 2 others practice farming very minimally
(c) active males above six years old indicates potential labor for herding, farming and cattle management, actually they may be involved in schooling or off-farm employment

Source: Taylor-Powell, 1986

Table 4. Establishment and maintenance coats of a 4 ha. fodder bank in 1984

Establishment Costs Unit	No. of Units		Total Cost (Naira)
Strainer posts	5		310
Posts	75		375
Wire	2400	meters	840
Binding wire	500	meters	33
Transport	2	loads	80
Labor	14	days	70
Metal Fencing			1708 (US $2220.40)
Seed	40	kg	480
Fertilizer	600	kg	126
Total			2314 (US $3008.20)
Recurrent Costs			
Fencing	10%	replacement	171
Seed	10%	reseeding	48
Fertilizer	400	kg	84
Labor	9	days	45
Total			348 (US $452.40)

Source: NLPD Records, 1985

Table 5. Effect of different land preparation methods and seed treatment techniques on establishment of S. guianensis cv. cook 6 weeks after planting

Land Preparation Method	Seed treatment techniques Mixed with sand	Mixed with dung slurry	Insecticide dressing	Mean
	(sand count/sq meter)			
1 week intensive kraaling	150	76	167	137
2 weeks grazing before sowing	69	99	67	78
2 weeks grazing after sowing	205	176	212	197
Burning in the dry season	45	195	133	103
Mean	117	137	133	-

Source: Mohamed-Saleem, 1986

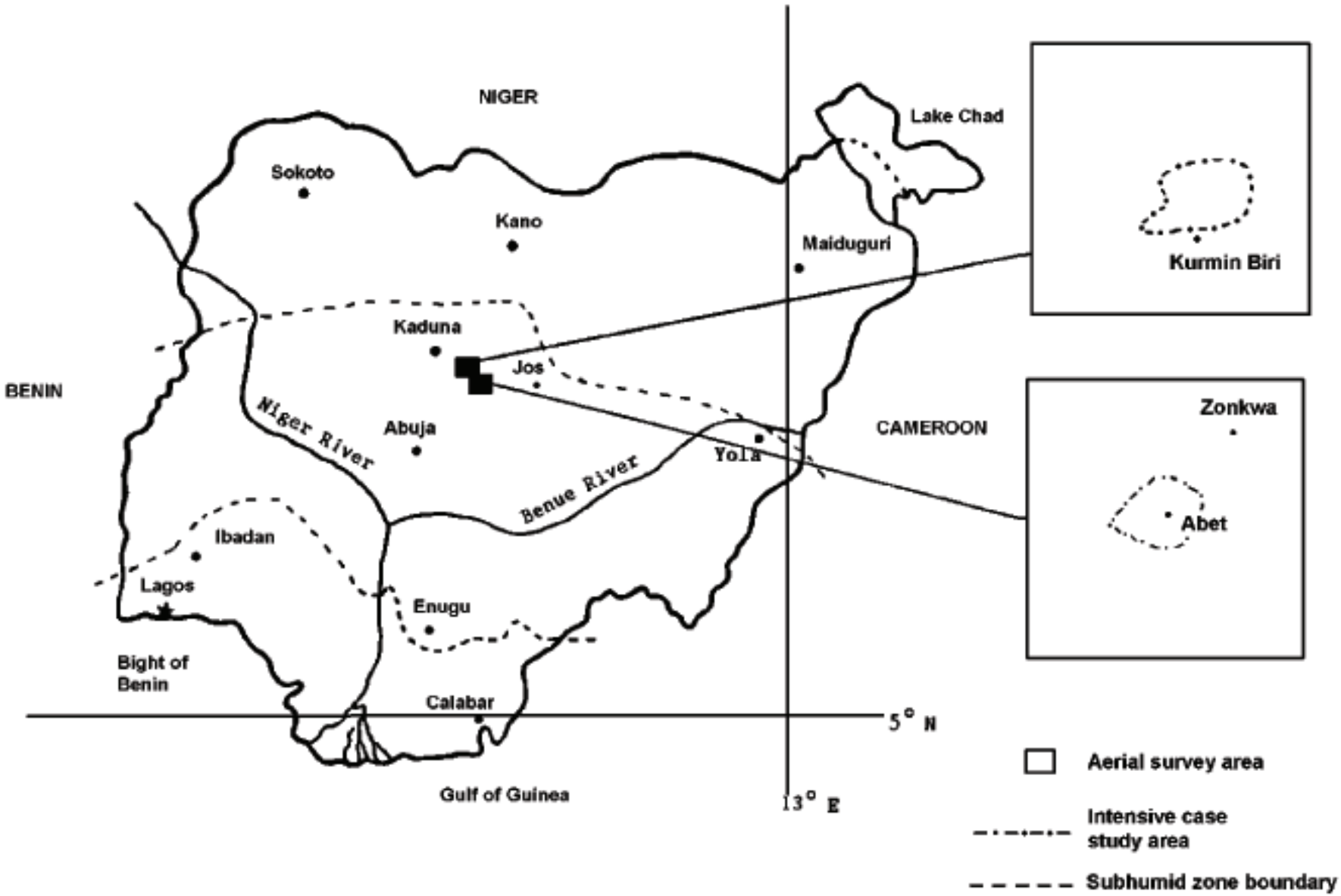

Figure 1. Map of Case Study Areas in the Subhumid Zone of Nigeria

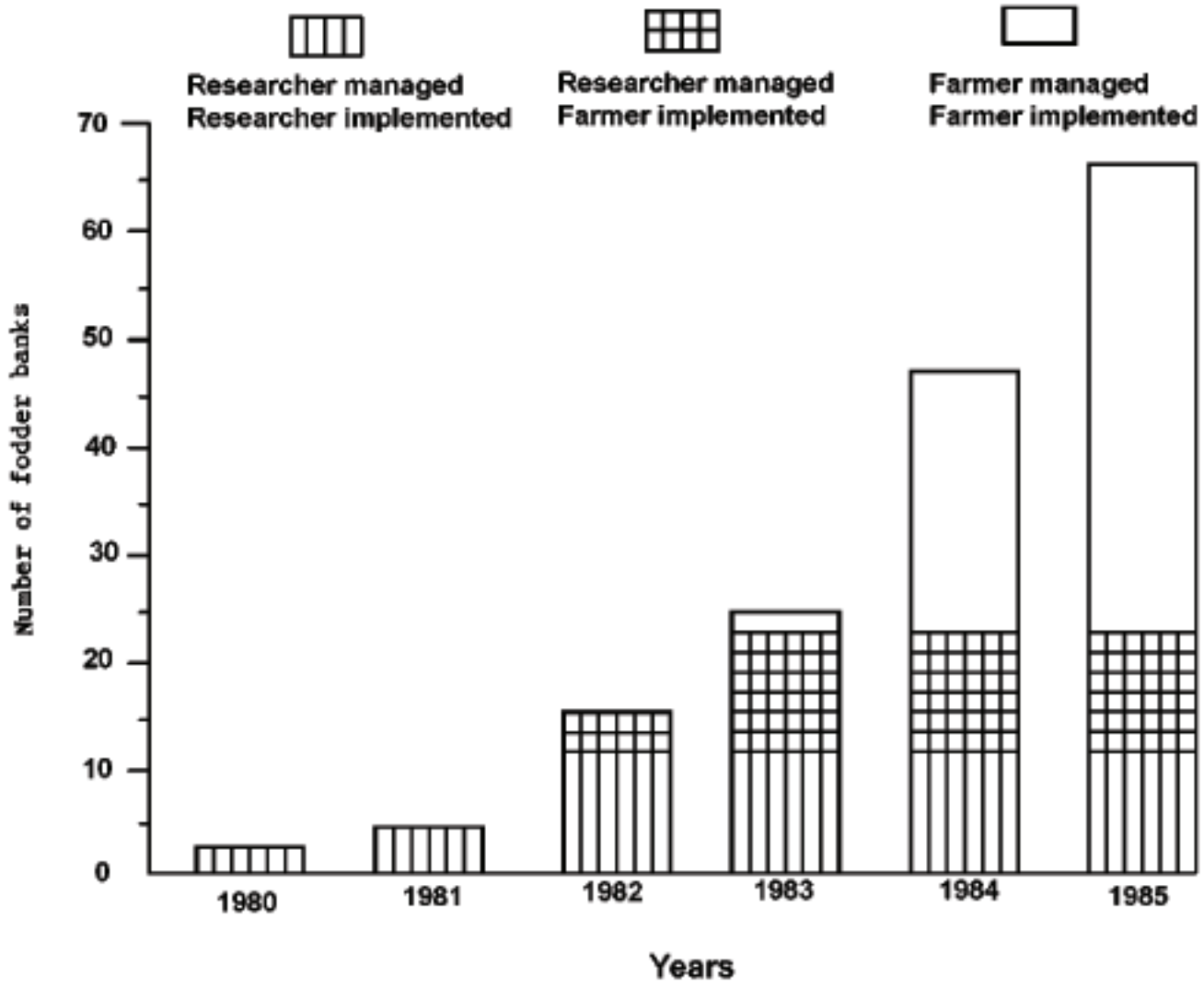

Figure 2. Number of fodder banks at various levels of management in the Nigerian Subhumid Zone.

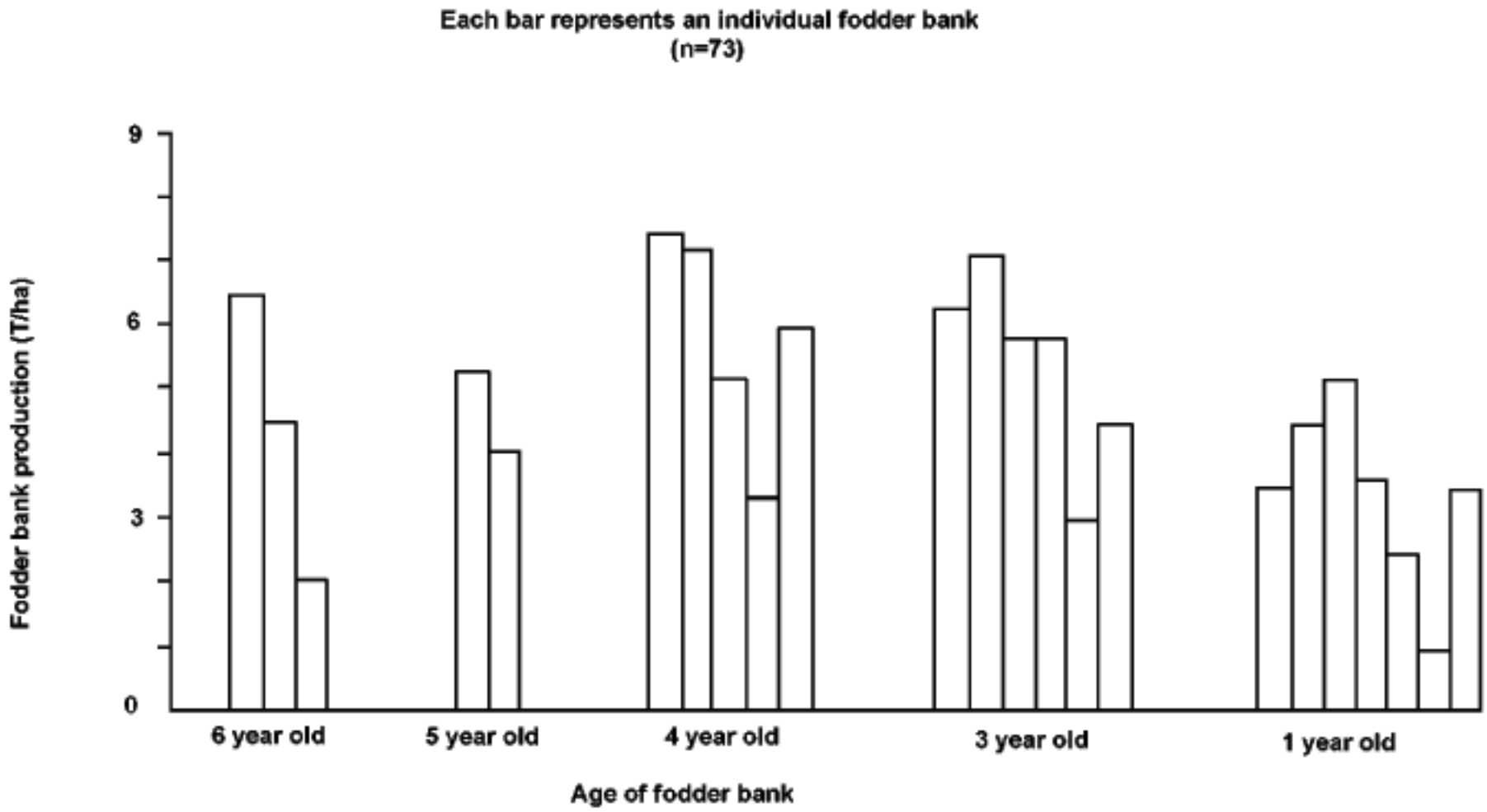

Figure 3. Age and productivity of selected fodder banks in the Nigerian Subhumid Zone, 1984/85

Source: SHZP survey data

RECOMMENDATION DOMAINS AND THE DESIGN OF ON-FARM RESEARCH AND EXTENSION IN LESOTHO

Mavuso Tshabalala and David Holland

INTRODUCTION

The need for the research reported in this paper arose from previous analysis which found Lesotho's rural population to be characterized by considerable economic differentiation (Holland (a), Eckert). Surrounded on all sides by South Africa, the development of Lesotho's economy has been strongly conditioned by the needs of the South African economy. Presently Lesotho functions as an important supplier of labor power to South Africa while simultaneously depending upon South Africa to supply much of its (Lesotho's) food and other necessities. For Lesotho's agriculture, the historical transition has been from an exporter of wheat and livestock products to South Africa to an importer of basic food grains.

While the level of productivity and commercialization of Lesotho's agriculture is relatively low (Holland (b)) in common with many other African countries, the situation is none the less quite different. The main difference is that peasant producers (a major group in many African countries) represent a relatively small proportion of rural families in Lesotho, who are mainly dependent upon the sale of their own labor power (i.e. wage work) for a majority of their family income.

Farming, for many of these families, while important as an additional source of real income and as insurance against the loss of wage work is very much of a part-time mainly subsistence oriented activity. Off-farm wages are not invested in basic tillage equipment or draft power judging by the low level of ownership of these production inputs. This is probably explained mainly by the low return associated with agriculture and the extremely low wages of black employees in South Africa, which, once basic family needs are taken care of are not sufficient to allow much surplus for saving or investment. Rather agriculture must provide a supplement to wage payments in the reproduction of labor power.

It has been previously recognized that this situation has implications for agricultural development that make it important to distinguish between genuine peasant producers and producers who are more correctly seen as mainly wage workers. In the peasant case, the family is totally, or nearly so, focused on agricultural production. The basic agricultural development problem may be defined to be the need to increase productivity and production and then to orient this increased production to the market. The peasant producer has had little or no experience with industrial sector wage labor and little access to it.

The point is that agricultural development is likely to be a somewhat different and more complex proposition in the case of wage-worker farmer than in the case of those societies where wage labor has not penetrated extensively into traditional agriculture. However, while there is some understanding of these aspects of the Lesotho situation there has been only one previous study

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(Eckert, et. al.) of how the economic and social differentiation that exists in rural Lesotho could be used in shaping agricultural development strategies. The study described in this document is similar to Eckert but gives particular attention to the implication of these findings in shaping agricultural research and extension programs in Lesotho.[1]

This paper describes the results of a study of the economic and social stratification of the rural population of Lesotho and its possible implication for research and extension planning. The approach is basically the same as that suggested by CIMMYT (Collinson) where recommendation domains are identified and become the basis for grouping farmers into somewhat homogeneous target groups who share most of the same agricultural constraints and problems.

This paper will: (1) provide a set of economic criteria for further refining existing recommendation domains for Lesotho; (2) show how the rural population of Lesotho is distributed according to the defined recommendation domains; (3) illustrate how the recommendation domains are related to other social and economic characteristics of Lesotho's rural population; (4) compare the findings of this study with Eckert's earlier work; (5) summarize the findings regarding the usefulness of the recommendation domains.

SELECTION CRITERIA FOR RECOMMENDATION DOMAIN AND SOURCES OF DATA

An individual farmer's farming system is the product of natural, economic, and cultural circumstances as well as the farmer's own goal and resource endowment. In Lesotho, like most other African countries it is natural and climatic differences between different geographical zones that have been the main factors in the identification of recommendation domains. The lowlands, foothills, and mountains have been identified as distinct ecological zones each having somewhat different agricultural problems. Different agricultural research programs are carried out by the Agricultural Research Division in prototype areas representative of the lowlands, foothills and mountains ecological zones. Differences in research programs are mainly due to perceived differences in climate (i.e. rainfall and temperature). The prototype areas are Siloe, for the southern lowlands; Nyakosoba for the foothills; and Molumong for the mountains.

In this study, economic criteria are used to suggest a further delineation of recommendation domains. Several of the criteria used to identify recommendation domains were mentioned in the previous section. It was noted that at one extreme there are full time resident Lesotho farmers who control a full complement of agricultural resources—land, labor and capital. At the other extreme there are rural families in which the household head is employed on a contract in South Africa and the family controls very little land or agricultural capital in Lesotho. The three main criteria for grouping the rural population into recommendation domains were the families' control of the basic resources necessary for field crop farming—land, labor and capital. As will be seen, most rural families in Lesotho do not control this basic complement of resources, yet they still continue to produce some crop from the fields. While more will be said of the institutions that surround this condition it is clear that access to resources imposes radically different farming systems on neighbors in the same ecological zone.

Labor availability was measured by presence or absence of the household head as a full-time resident of Lesotho (Table 1). As previously noted many heads of households work in South Africa on long-term mining contracts. As a result, for most of the year, they cannot devote their labor nor much management to agricultural activities in Lesotho.

Land was measured by the ownership of fields (Table 1). We were especially interested in identifying those land owners who had at least enough fields to produce a crop whose value would be competitive with wage work in South Africa. Such individuals would have at least the land resource to make field crop farming economically interesting. The criteria for identifying these significant land owners was ownership of two or more fields.

Two different criteria were used in connection with agricultural capital (Table 1). It was clear from previous work (Holland (a): 30) that many people who farm do not own tillage equipment or oxen. As a result, if they have fields to farm they must depend on borrowing or hiring the oxen and the implements. Since a relatively high number of "farmers" are in this position of non-ownership, a relative shortage of this capital develops and the result is often hastily done and poorly prepared fields in which operations have often been carried out well past optimal planting dates.

The main tillage implements (ox-drawn) used to prepare and plant fields in Lesotho are the plow, the harrow, the row planter, and the field cultivator. Farmers were classified as making a significant investment in equipment if they owned at least three of the above four implements. The criteria for oxen was ownership of at least two oxen. Two oxen are necessary for planting and field cultivating and can be used for limited field plowing. Ownership of at least a cultivating team gives the farmer much greater control of the timing of necessary field operations.

Using the previously discussed criteria ten separate recommendation domains were identified, with two residual categories serving to catch those households not classified into a specified recommendation domain. Since the migrant status of the household head was believed to be very important in determining the individual farming system and because this variable was non-quantative, the recommendation domains presented in Table 2 were first stratified into resident and migrant categories. The remaining stratifications were based on the criteria summarized in Table 1. Moving down the domains in Table 2 one moves from the resource rich farmers, group Rl, to the resource poor farmers, groups R5 and M5.

The actual grouping of the rural population according to these recommendation domains is based upon data collected by the Baseline Survey conducted by the Lesotho Farming Systems Research Project. The survey was administered in 1981 to 441 households located in three prototype study areas (Butler). Thus, the data represent not only the lowlands, but the less commonly studied foothills and mountain regions as well. Approximately a fifteen percent random sample of households in each prototype area was taken except for Molumong where the sampling rate was twenty percent. Once the criteria associated with each recommendation domain were chosen the sampled households were further stratified into the groups identified in Table 2 by hand sorting the questionnaires from the Baseline Survey.

DISTRIBUTION OF HOUSEHOLDS IN THE RECOMMENDATION DOMAINS

The distribution of the rural households in the recommendation domains is presented in Table 3. For further clarification, the results of Table 3 are also presented in Figure 1. We found that a substantial proportion of rural households, 32 percent, lack all the three basic agricultural resources: land, oxen, and equipment. A majority of such households are migrant headed while for the total sample the proportion of residents is higher than the proportion of migrants, 62.4 percent and 37.6 percent, respectively. Looking at the data for the three prototype areas indicates regional differences. Molumong and Nyakosoba have a higher proportion of residents than migrants in the category that lacks resources. Siloe, on the other hand, has a higher proportion of migrants than residents.

The group owning at least one of the basic agricultural resources (fields, oxen, equipment, or some combination) forms 68 percent of the sample. A majority, 46.9 percent, are residents; migrants are relatively few, 21.1 percent. Breakdown of data by prototype area shows similar distributions.

SOCIAL CHARACTERISTICS OF FAMILIES IN THE RECOMMENDATION DOMAINS

The social characteristics: sex, age, marital status and education are presented in Table 4. De jure male headed households are greater in percentage than female headed households, 77.1 percent and 22.9 percent respectively. However, by observing that a majority of migrants, 37.0 percent, are males and that females (wives of migrants) manage migrant households on a daily basis, then de facto male and female headed households are 40.1 percent and 59.2 percent respectively. A majority of male heads are married with a small proportion of widowers. A majority of the female heads are widowed with a small number of separated females.

While the degree of ownership of agricultural resources is generally low, this is more pronounced among migrants and resident female heads. In fact, resident female headed families and migrant families are heavily concentrated in the land only and no agricultural resources groups (R3, R5, M3, M5). Female headed households make up 56 percent of the R3 group (Figure 2). The average age of this group is nearly 60 years.

The average age of residents is significantly higher than the average age of migrants within comparable groups. It is likely that many of the resident household went through the migration cycle in their younger years. Generally, groups with at least one resource have higher average ages, and groups with no resources have lower average age. The relationship between age and degree of resource ownership is not, however, linear but variable. Surprisingly, the relationship tends to be positive for the resident groups and negative for the migrant groups. That is, for residents, as the degree of ownership of resources increases the average age increases and vice versa. Education does not exhibit a significant relationship to ownership of resource or to residence of the head of household.

PRODUCTION

The crops considered in Table 5 are maize, sorghum, and wheat because they are most important in terms of the proportion of fields put to them. For

We have made suggestions along those lines in this paper based on our stratification of the rural Lesotho population into recommendation domains. Of course more work is required to verify our hypotheses regarding the particular research and extension focus for the specific groups we have suggested. While it is probably too much to expect all of these suggestions to be incorporated into future agricultural research and extension efforts, it is vitally important we believe that future programs incorporate the essence of these ideas. In general, future research must incorporate social scientists, especially economists and sociologists into the research design and execution stages of on-farm trials. Simply asking the social scientist to come in at the evaluation phase of the research will not suffice.

The resident group - R2 having oxen and land and R4 with oxen only - offer, perhaps, the most interesting groups for a research/extension program both in terms of immediate agricultural impact and longer term broader based economic impact. These groups have most of the necessary agricultural resources, but their land productivity remains low in comparison with Rl. With increased investment in field equipment it is likely that their productivity would approach that of group Rl. Since the necessary technology is already developed in Lesotho today, all that may be required is mainly an education and extension program demonstrating the benefits from such technology to these groups. The focus of such a program would be on the advantages of proper seedbed preparation and the use of a planter to plant the crop. It is also possible that constraints other than lack of knowledge such as lack of credit are more binding. With little additional research these issues could be sorted out.

Since the R2 and R4 combined group is relatively large, the corresponding supply response would be large if the program of technology diffusion were successful. Such a program should include attention to improved seed and the correct use of fertilizer since those factors are the source of part of the benefits of using a planter. However, both hybrid seed and fertilizer must be imported from South Africa. The nice thing about increased investment in tillage equipment is that with appropriate linkage it can be manufactured in Lesotho and can generate jobs and income locally which increased use of fertilizer and seed may not.

Another group with low productivity, but seemingly great potential for improvement is the migrant group - Ml. They own all necessary agricultural resources, have wage income, and are young, but still have very low yields. A possible explanation is a severe labor constraint given the requirements of a young family and a wage job and the required agricultural work. If the problem is a shortage of labor perhaps a program on shared decision making could be developed. If the wife could be given more discretion and encouragement in the organization or hiring of labor and purchase of the necessary inputs perhaps productivity would increase. Another possible explanation is simply lack of technical knowledge on how to take proper advantage of the improved technology that is owned. The main problem in working with this group is the absence of the head of the household. Certain key aspects of any such program would have to be timed to when the household head is home.

CONCLUSIONS

Perhaps the main point to come out of this work is the importance of specifically considering economic and social factors in designing agricultural research and extension. The "average" farmer is a myth and programs designed to help him will fail. On the other hand, programs designed simply to increase yield potential will have very little impact in Lesotho. As previously noted most of the farmland is held by families without the agricultural resources necessary to capitalize on most yield increasing technology. And many of these families cannot be expected to be interested in ever obtaining that technology. The key to having agricultural research and extension payoff is matching the improved technology to the group likely to be interested in taking advantage of it.

timeliness will be beyond their response capacity (i.e. optimum planting dates, long season hybrids and winter plowing). Likewise technology dealing with fertilization or optimum plant population is likely to be uninteresting as well because such families own neither the tillage equipment nor the oxen to execute such improved procedures.

Many of the families falling into this category (without oxen) are likely to have very little money from outside sources—in particular groups R3 and R5 are for all practical purposes incapable of responding to any kind of a program calling for purchased agricultural inputs. A large portion of these groups will be subsistence farmers. In Eckert's work, this target group is mainly identified as the part-time farmers and he includes some families with off-farm income in this group. While we feel it makes more sense to exclude families with off-farm income from the strictly subsistence group, we are in agreement with Eckert regarding the implications for agricultural research and technology for the subsistence group.

First it must be recognized that most interventions of improved agricultural technology are not going to do much for this group. The kind of agricultural program that may be appropriate for some of these families would involve varieties of crops that will out-perform the farmers own varieties when grown in the same way that the farmers grow them. The seed must be open pollinated and not require fertilizer to perform well. Based on admittedly sketchy research of this type it seems likely that Highland White Flint maize for the mountains may be such a crop. Pinto beans also seem to be a likely candidate. The other major program that can be suggested for this group is a management strategy that emphasizes the importance of crop rotation rather than planting the same crop on the same field every year as is common.

Group R3 which is the source of much of the land that is share cropped and/or left fallow contains a high proportion of owners who are elderly women. Eckert suggests trying to develop programs to stimulate increased leasing presumably to more productive farmers to increase rental income. Our research raises an additional question. What is the M3 group (counterpart to the R3 group) doing that the R3 group is not doing? Recall that the M3 group enjoyed the highest productivity of any of the migrant groups. Perhaps the difference is simply increased use of purchased inputs by M3, something that is not possible by R3. In any case increased study of Group M3 may result in a strategy for improving the productivity of R3.

On somewhat the same theme, it needs to be recognized that many families in rural Lesotho—mainly in groups R5 and M 5 — are going to be unable to respond to any kind of an agricultural technology improvement program involving field crops. They simply don't have the agricultural resources. Eckert suggests that "the most important item that could be provided would seem to be an off-farm job". Although his target group does not correspond perfectly with ours, this seems to us to be good advice. As far as agriculture is concerned programs on home gardening or small livestock may make sense for some families interested in agriculture. Generally, however, off-farm job creation programs or perhaps even some form of old age social security program for the older residents in this group would seem to be most appropriate.

the total sample, maize occupied 40.0 percent of the cropped fields, sorghum occupied 24.2 percent, and wheat occupied 22.9 percent. Beans and peas occupied 5.8 percent and 7.2 percent, respectively. Breakdown of data by area show that maize was important in all the three areas: 42.3 percent in Molumong, 47.6 percent in Nyakosoba, and 26.6 percent in Siloe. Sorghum was most important in Siloe, 59.1 percent. Wheat was important both in Molumong and Nyakosoba, 25.8 percent and 29.9 percent, respectively.

We expected that the resource rich groups would exhibit higher land productivity and higher total production per household. For residents, the resource rich group, Rl, consistently had a higher production per field and higher production per household and there is clearly a tendency towards a positive relationship between productivity and degree of ownership of resources. That is, as the degree of ownership of resources increases production per field and production available per household increases. The resident group without resources, R5, generally had the lowest production per field and per household (Figure 3).

For migrant households a similar relationship was not observed. The migrant-land-only group, M3, had surprisingly high production per unit field and per household while Ml tended to have lower production per field and per household than M3. We know that group M3 depends more heavily upon sharecropping-out than either Ml or M2. One possible explanation of the higher maize and sorghum yield for M3 is that the sharecroppers who use land from M3 are able to farm better than are the migrants because they devote more time to farming during various critical periods.

The finding that was most surprising was that migrant groups often had yields as high as their resident counter parts. We expected that the obvious lack of male labor would lower the land productivity of the migrant groups compared to the resident groups. The one grouping where that expectation was verified was for the group controlling all agricultural resources. Group R1 exhibits consistently higher yields than group Ml. For the other groups, however, this consistency was lacking.

It is possible that increased use of purchased inputs may just offset the lack of male labor; with the result that migrant group productivity is roughly equal to resident productivity. At this stage the preceding explanation has not been tested, since data on input purchases have not been assembled by recommendation domain.

DISCUSSION

While the previously described stratification of the rural population into recommendation domains is believed to have uncovered some interesting differences between groups, the real question is whether the recommendation domains provide a useful guide to the organization of future research and extension efforts. We believe that the answer is affirmative and will suggest some of the implications of this analysis for future program direction.

The importance of relating ownership of agricultural resources to programs for agricultural technology improvement is clearly revealed by the data summarized in Table 3. Sixty four percent of rural households in Lesotho do not own a span of oxen. Agricultural technology involving any aspect of

FOOTNOTES

[1] Eckert's work does identify target groups, but they are not uniquely classified. In other words, the same classification of farmer may fall into more than one target group and a particular target group may have two somewhat contradictory classifications of farmers in it. While we regard Eckert's work as basically correct in attempting to identify target groups, we also believe that the lack of clearly defined criteria for the target groups limits their operational usefulness.

[2] Our definition of groups left out only 2.2 percent of the rural households, which are, here, grouped together as "unclassified": They own either equipment only, oxen and equipment or land and equipment.

[3] All percentages in this report, unless otherwise specified, refer to percent of the total sample (N = 441).

[4] Households with a female migrant head make up the remaining 0.69 percent of the sample.

[5] In some cases the new technology will be even out of the reach of the resource rich farmers.

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Table 1: Classification Criteria for Identification of Land, Labor and Capital Resource Categories

Resource Category	Classification Criteria
Labor	Residence of the household head
Land	Ownership of at least two fields
Capital	Ownership of at least two oxen
	Ownership of at least three field implements

Source: Author’s estimates.

Table 2. Selection Criteria for Recommendation Domains

Ownership of Resources	Household Head	
	Resident	Non-Resident
Land (at least two fields) Oxen (at least two oxen) Equipment (at least three implements)	Group R1	Group M1
Land (at least two fields) Oxen (at least two oxen) Little or no equipment (no more than two implements)	Group R2	Group M2
Little or no land (no more than one field) Oxen (at least two oxen) Little or no equipment (no more than two implements)	Group R4	Group M4
Little or no land (no more than one field) Few or no oxen (no more than one ox) Little or no equipment (no more than two implements)	Group R5	Group M5
Unclassified	Group R6	Group M6

Source: Author’s Research

Table 3. Number and Percent Distribution of the Rural Population According to Recommendation Domains: Molumong, Nyakosoba, and Siloe (N=441)

Ownership of Resource	Molumong		Nyakosoba		Siloe		All	
	R[a]	M[a]	R	M	R	M	R	M
Land	11	2	5	4	4	1	20	7
Oxen	9.6[b]	1.7	3.3	2.6	2.3	0.6	4.5	1.6[c]
Equipment								
Land	16	6	32	14	22	6	70	26
Oxen	13.9	5.2	20.9	9.2	12.7	3.5	15.9	5.9
No equipment								
Land	21	6	28	8	48	21	97	35
No oxen	18.3	5.2	18.3	5.2	27.7	12.1	22.0	7.9
No equipment								
No land	20	17	28	16	20	40	68	73
No oxen	17.4	14.8	18.3	10.4	11.6	23.1	15.4	16.6
No equipment								
Unclassified	1	2	1	3	3	0	5	5
	0.9	1.7	0.6	2.0	1.7	0.0	1.1	1.1
Total	75	40	100	53	100	73	275	166
	65.2	34.8	65.4	34.6	57.8	42.2	62.4	37.6
Sample	115		153		173		441	

[a] R stands for Residents; M stands for migrant perfume flown

[b] Percent of the Molumong sample

[c] Percent of the total sample (N=441)

Source: Baseline Survey, Farming Systems Project, 1981

Table 4. Social Characteristics of Households According to Recommendation Domains

	R1	R2	R3	R4	R5	R6	M1	M2	M3	M4	M5	M6
No. of households	20	70	97	15	68	5	7	26	35	20	73	5
Sex of head of household:												
Male	16	61	44	12	40	4	7	26	33	20	72	5
Female	4	9	53	3	28	1	0	0	2	0	1	0
Marital Status												
Married	16	58	34	10	38	4	7	26	32	20	71	5
Widow	4	12	59	3	26	1	0	0	3	0	1	0
Separated	0	0	4	2	4	0	0	0	0	0	1	0
Average age	59.4	55.6	59.1	51.4	47.4	57.4	42.4	45.5	47.1	38.2	34.7	49.4
Average education	4.0	3.0	3.4	2.6	2.6	3.2	3.0	3.0	3.1	3.6	3.5	4.6

Source: Baseline Survey, Farming Systems Project, 1981

Table 5. Production of Tins* of the Three Major Crops by Groups

	Groups									
Production	R1	R2	R3	R4	R5	M1	M2	M3	M4	M5
MAIZE										
Total production	1231	1444	1228	163	410	207	581	1214	134	298
Average per field	31.6	18.0	15.0	16.3	15.1	20.7	19.4	33.9	13.4	11.5
Average per household	61.6	20.6	12.7	10.9	5.9	29.6	22.3	34.8	6.7	4.8
SOURGHUM										
Total Production	486	561	808	27	124	32	144	612	42	379
Average per field	28.6	11.9	12.8	5.4	9.5	6.4	13.1	21.8	42.0	15.8
Average per household	24.3	8.0	8.3	1.8	1.8	4.6	5.5	17.5	2.1	5.2
WHEAT										
Total production	538	1326	1122	405	113	124	443	251	111	97
Average per field	28.3	22.5	22.9	27.0	11.3	24.8	23.2	22.8	18.5	13.8
Average per household	17.9	18.9	11.6	27.0	1.7	17.7	17.0	7.7	5.5	1.3

*All figures on production and averages are measured in the tins. (20 liter tins)

Source: Baseline Survey: Farming Systems Project

DIAGNOSTIC FOR THE RESEARCH AND TRANSFERENCE OF TECHNOLOGY IN AGROSYSTEMS

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Farmers and dynamics of the Regional Agriculture

The diagnostic for the research and transference of technology has as its primary goal to be ruled by the knowledge of the laws that develop the agriculture in its context of social complexity. Such laws are fundamentally of human nature and have been created in order to arrange the social relations. Among them, has been articulator the application of such relations to norm the ownership and management of the resources. In the current historical situation of the agriculture, it can be dimensioned to the maximum level of complexity because of its participation for example, in the international market, or, as the opposite case, the peasant agriculture that produce the total or a big part for auto consumption and often sells its labor force regionally.

The dynamics of the modernization or not of the agriculture and basically of the production systems that compose it, will be supported by different type of social relations based on the historical facts that conform it in a particular way.

In such a context the agronomy is defined as a interdisciplinary scientific practice that concerns the study of the behavior laws of the nature when it is subordinated by means of technological resources. Such resources are to be finished to produce goods on the base of coherence and in the contour of a socio-historical process.

The schedule actions that structure the present research has as its goal, as a consequence, to contribute-hopefully-to the development of the technological management of the reduction systems generated by the farmers, to improve its efficiency and the quality of the management of their resources.

The structural conditions to implement actions in the farmer’s conditions are limitative due to the low availability of financial

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and methodological resources, in front of the requirements of the research due to the time-space organizational diversity of the agriculture.

The preliminary space limits of the diagnostic are defined with the limits of the Development District. This obey to the fact that the demand and utilization of the research products, are canalized by means of the Rural Development of the Ministry of Agriculture-as programming units of the development-.

The area of interest involves 320 thousand ha., prevailing the area under agricultural use with 194 thousand ha. (61%), the forestall area is equivalent to 22% and the one with cattle utilization 10%.

The rainfall agriculture sums to 149,500 ha. That represents 77% of the total agricultural area.

By considering the ownership regime, the common land occupy 91% of the total area of the District and the private property 9% SARH (1984).

The structural characteristics with the above data about the district justify the comparative analysis within the sector frame, being this contour in which the agriculture is englobed. As a product of such a correlation there is a recent national tendency to privilege the accumulation of resources and capital towards the urban instances via the transference of value. As a counterpart, the recent evolution of the peasants-conformed basically by the people in the common lands of the region- is explained within a reduced scheme of managed of the productive resources and often in deterioration of the existent resources, Appendini et. al.(1985).

The peasants in Mexico represents 75% of the farmers, and among them, the majority is less than or equal to 4.0 ha. Of rainfall agriculture, CEPAL (1982)

Based in the veracity of the above social processes, it is intended to justify that the research about the agriculture must utilize some levels of analysis that will permit to explain its behavior by operative instances of complexity.

These instances have been defined functionally with our objectives in: agricultural systems (agro systems) that compound the district, family production systems that implement the possible types

of agriculture within the agro system and the crop systems structured within the logic of the production systems.

The notion of agro systems is justified methodologically towards the delimitation of functional areas with certain characteristics of homogeneity that facilitate the program actions, same if they conform spaces as a differentiated continuum. The production systems in its diversity of process combinations carried out by the farmers, intra and extra system conform an agro system that has been defined by a relative treatment of environmental homogeneity. By consequence, it is hypothesized that the organizational diversity of the production systems can be analyzed with major rigorism as answer to its dynamics, different from the social relations.

For the interdisciplinary study of the agriculture it is proposed as articulator factor the analysis by means of limitative factors. The social sciences in rural studies tend to consider the environmental factor as constants occurs in the agronomic studies.

In the production system are concreted the social historic processes and the action of the structures, with this delimitation the decisions are taken to get related by means of technology with the environmental quotidian contingency.

The population of the development district is 390 thousand inhabitants and the economically active population (EAP) comprises 36%. The EAP in the agriculture represents 57% of the total.

The productive structure shows that the more important crops are corn, wheat and kidney bean, with an area of 141,752 ha. (89.3%); among them, the corn is principal crop with 132,381 ha. That represents 83.3% of the total. The wheat represents 3.4%.

The behavior of crops above in time series between sown annual areas and harvested, whose difference is the loosen area due to sinister, it in relative and absolute terms more important for corn. The corn crop is the more sinistrous and however constitute the principal cultural alternative of the reproductive strategy of the peasants.

The events like frosts, hails and availability of humidity during crop time constitute the principal weather limitative factors.

In summary, is the corn the principal productive activity in the production systems as well as in the agro systems, as a consequence is the more important income source and the cause of variation of it.

Therefore the gate to the regional analysis and for the different levels was to privilege the knowledge of the corn management, on the base that the corn is the more important crop and it is carried out under a diversity of productive processes. The corn productive problematic contributes in a significant way to the definition of the regional problematic, Montanez and Warman (1985).

The delimitation and characterization of the agro systems

The development district is located in Mexico State, between $19^0$26′ and $20^0$00′ north latitude and $99^0$28′ to $99^0$59′ west longitude. The principal agricultural valleys are located between 2400 and 2550 m. above the sea level and do cover an approximated area of 61.5 thousand ha. The rest of the agricultural grounds are mounds and mountain zones, within an altitudinal variation range of 2550 to 2950 m.

The initial delimitation of the agro systems was based on the geographical classification of the principal soil units, as in the FAO classification; the delimitation of the dominant physiographical types; the height above the sea level accepting a delimited amplitude of variation, and finally, the areas with irrigation and rain fall agriculture (Table 1).

The weather information was also used with primary interest for the characterization of the agro systems, by considering the study of the limitative variables detected previously in 20 weather stations.

The utilization technique of the information has as its goal to represent cartographically the lines of iso-behavior to stratify the different agro systems. It was privileged the period between the last frost at 80% of probability and the first frost at 90% to define the growing period (fig 1.). Later, the available precipitation during the growing period was evaluated at 80% of probability, just as the computation of the heat units to the interior of such growing period, using as a base the 7 degrees Celsius. The above weather information was represented cartographically (fig. 2 and 3).

Based on the characterization of some structural elements of the district, additional to the environmental characterization schematized above, it was considered some elements to support the agronomic comparative analysis towards its hierarchization. Such ordination of the agro systems was done through confrontation of cultural aptitudes of the different agro systems. These aptitudes were analyzed by considering their requirements of agronomic management, the specifity of the different productive processes, the risks in the family production systems and some results of its management.

Following the ordination of agro systems, the analysis of the information of the counties involved in a significant way within its limits was done. The action before was done to ratify the existence-and its terms- of the structural characteristics that were analyzed as interesting with in the contour of the regional behavior.

As a product of the joint analysis within the group, two agro systems were considered as of primary interest, and it was scheduled some deeper and detailed actions.

In light of the proposed methodological scheme, actions were taken to characterize in a short time the principal productive activities of the family production systems and the productive processes operating in the crop systems. The modeling of the organizational productive units of the agriculture in its different levels and mutual social determinations will be done later.

Structural elements of the production systems and notes about its functioning

Two agro systems were selected for a deeper actions program: The Valley of Ixtlahuaca-Atlacomulco (VIA) and Height Valleys and Mounds (VALA). To exemplify the methodology, the actions in VALA will be discussed, as will as the obtained results and the proposed diagnostic activities for 1986.

To the agro system level, it was considered that the farmers and their relations much be investigated as the articulator components within the space where the systems is constituted. The dynamic of the agro system being a product of the interaction between the producers and the existent social relations regionally-an aspect that is intended to define as an agrarian system.

To characterize the production systems it was privileged during

1985 two types of information: productive structure of the system and the analysis of the technological management of the representative crop system.

In the general characterization of the agro systems it was presented to conceptual discussion and the figures 1 to 4. In addition, to contribute to the knowledge of some socio-economic and environmental indicators specified in the farming system research guideline, in the follows we present the fundamental global characteristics for the VALA agro system.

The representative ethnic type is mazahua, with supposed filiations of the nahuatl group. The agricultural area is 27,000 ha. approximately, and the corn represents 93%. The corn crop is mono annual, the sowing finish by the first April fifteenth and the harvest starts with November. The general condition of residual humidity allows to seed 1 or 2 months before the beginning of rain fall.

From COMPLAMAR (1982) the agro system population is characterized by the next socio-economic population indicators: rural population 92%, low income population 83%, part-time job 44% economically active population in agriculture 78% low consumption of eggs 79%, illiterate 57%, general mortality 20%, pre-school mortality 41%, households without water 84%, and households without electricity 90%. Low consumption if when ingestion is less than or equal to 2 days per week.

The dominant soil unit (95%) is andosol which due to its physical chemical characteristics behaves in a very specific way. This type of soil has volcanic origin and has a chemical behavior that fixes important quantities of the available phosphorus. Recently have been reported troubles of nitrogenized nutrition in another andosol region, which is the Purepecha (Tarasca) region; II Seminario de andosol (1986). They are soils with acid PH (4.8 to 6.8) The structure is granular and the texture is mainly arenaceous-crumb.

The survey was directed to 11 communities justified by their geographical location in order to apprehend different possible types of production systems. The surveyed people were mainly from common land (86%), however, there were small owners (9%) and people with both types of tenancy (%).

From the survey results, 86% of the families have 8 or more people. The combination of the available family work is oriented

mainly to diversity of productive activities within the systems. In 46% of the production systems there is at least one member that sells its labor force out of the system, and the dominant occupations are mason and laborer, characterized by being occasional during the year. The hiring of labor force is almost null and when it is practiced, it is occasional and reduced.

The size of the plots fluctuate from 0.5 to 10 ha., the more important concentration is between one to three ha. With 72% of the farmers.

The combinations of productive processes to the interior of the systems have permitted to identify like principals: cattle raising, fruit trees, some people practice the extraction of a special type of grass, and the corn production as fundamental in the soil use (fig. 5).

Cattle raising is practiced around the dwellings and sometimes pasturing in common lands, basically for auto consumption, reproduction of the work animals, and occasional selling. The animal inventory is compound by creole species of domestic fowl, bovines, ovines and caprines. With respect to the management, there are reports about forage scarcity during spring summer and the presence of diseases.

There are a few fruit trees, in combinations of apple, peach, plum and capulin. They are established around the dwelling and for family consumption. In the management are utilized creole species, there is no pruning, no fertilization and there are reports of diseases.

The farmers have credit available for corn, but only 24% of them. In average of two years, 76% did not sell corn.

The work process for corn is made fundamentally with yoke of draft animals and manually. The ground preparation, the sowing and crop labors are made with yoke of draft animals by 93% of the farmers, from which, only 51% have their own and the others have to hire it from neighbors.

The totalities of farmers utilize creole see, being the dominants the white type (60%) and the pink type (78%).

The more used technological component is fertilization, practiced by 94%. The agronomic research recommendation is 90-60-00 with the application of 1/3 of n and the total of P during

sowing: the rest of N in the second weed hook. As a comparison, 96% of the farmers apply the fertilizer in only one occasion mainly at sowing. With respect to the recommended formula, 27% apply less, 27% use the recommended levels and 48% apply superior levels that fluctuate till double that recommendation. This last group justifies that “the soil lose force”. Approximately 63% of the farmers apply organic manure in a fraction of the plot depending of the available quantity. It was reported that this was a generalized practice till 7-10 years ago. In opinion of some farmers the less use of manure of animal origin is due to the diminishing number of animals in the system, caused by diseases and recently to the increment of the minimum wages and lack of wage earners in the rural area.

The weeks control by chemical products is made by 17.5% of the farmers, the rest make manual control. The pesticides are used by 3.5%

The yield is variable among farmers and among years. For a one year period, 41% of the farmers got a yield less to 1 ton., 39% from 1 to 2 tons. and 20% got a yield superior to 2 ton.

The yield results show a diversity, particularly a potential to 3 ton. In the agro system, under certain management condition and with no limitative weather conditions. This weather conditions have limitative weather conditions. This weather conditions have limited particularly last years by means of early hail and frosts. Both phenomena have been of very located spatial effect.

To evaluate the regionally recommended technology by the research, 5 validation plots were programmed in the VALA agro system, to validate technology produced experimentally. Such plots we established in grounds of the farmers having commercial management. In the same plot were compared the farmers management and the one proposed by the research. The results show that the hybrids were not adapted as compared with the creoles. The yield of the technological package proposed by the research was inferior, and in some favorable cases were similar. Some samples were taken in different crop systems, to estimate the productors yield.

To make the agronomic analysis of yield, the yield components were studied. From the result, the number of grains per unit area is the base of the yield variation, showing a sensible linear and positive behavior (fig. 6). This shows that the yield is determined during the time from sowing to flowing. Several important causes were detected. Low number of plant per area unity, hail storms during July (the female flowering took place the first August fifteenth) and the low efficiency of plants to

produce spindleful.

To the level of the crop system the explanation of the yield variation are the management limitations, like the low sowing density, and particularly the fertility exertion, as shown by the variation in % of plants without spindleful . Furthermore, the number of grain per row was on the base of the variation of the number of grains spindleful, namely there were limitative conditions during the flowering period.

Conclusions and Diagnostic Actions to Short Term

The analysis of the agro system as a unity that involves socioeconomic and environmental terms, has made possible the study of the production systems within a context of determinations. To the interior of the production system, the behavior of the peasant economy was observed, showing a dynamic of diverse activities that structure the reproduction internal strategy by means of the joint work of several family components, some of them out of productive age. The duration of the family work is generally unlimited and without commercial accounting.

The input and output of row material and agricultural products are scarce. In the agriculture, the shopping reduced to fertilizers and eventually some manual work instruments. The market relations to sell agricultural products is not practiced by the totality of the producers, and when it occurs is limited to reduced sale of corn and some animals occasionally.

In the analysis of the peasant economy is essential to its comprehension the selling of labor force. The family work is related directly to the capital as a subordinated form.

When analyzing the mechanism that are structured in the peasant production system it is observed a series of reproduction strategies like organizational unities of production and of consumption and the selling of labor force. Such relations are given in socioeconomic disadvantage conditions and with a high probability of diverse risks, in the direct contour of a local space.

The continuation actions of the diagnostic have been oriented to the improvement of the soil fertility and to the control of the agro system deterioration. It was proposed in the technical committee of the development district to change the source of nitrogen to fertilize, knowing that the farmers use to by $(SO_4)NH_4$ and this tends to increase the soil acidity and

therefore to increment the problem of its chemical behavior.

The 1986 continuation actions were defined to advance in the diagnostic taking account of the problems and processes considered as having priority:

- validation of the technological package, during the second climatic year.
- Profitability and use of technology in the corn production process.
- Evaluation of the damage by the principal plant competitors identified the previous year.
- Study of the importance of the “arvenses” (growing in sown fields) in the peasant economy.
- Coherence and limitations of the fertility management in the Interaction fertilizer-organic manure.
- Typology of producers.
- Evaluation of biologic catalyses, by means of the ecologic study of native mycorriceae, to improve the efficiency of the fertilization in andosol soils.
- Evaluation of the potential of winter available humidity to produce forage through the utilization of oat and “ebo” (viciasativa) as mono-specific crop or as associated crop.
- training and diffusion of results to functionary and technicians of the district.

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Acknowledgements

To the surveyed agricultural producers for the given facilities to sample their plots.

To PH. D. J. Roberto Gomez A. for his advisory to the realization of the sampling and for the translation of the manuscript.

Table 1. Initial Critieria to the Provisional Definition and Characterization of the Principal Agrosystems

Agrosystem	Key	Estimated Agricultural area 1	Humidity condition	Representative soil units	Physiographical condition	height over the sea level
Valley of Ixtlahuaca, Atlacomulco	VIA	25,610	Initial irrigation and irrigation	planosol, feozem	Valley and small mounds	Around 2550 m
		28,190	Rainfall			
Valley of Temescalcingo	VAT	4,500	Initial irrigation and irrigation	vertisol	Valley	Around 2300 m
Valley of Acambay	VAA	3,200	Initial irrigation and irrigation	planosol, vertisol	Valley	Around 2350 m
Height Valleys and mounds	VALA	40,414	Permanently residual humidity	andosol	Valleys and Mounds	2600 m
Hillsides and mounds of the Ixtlabuaoa -Atlacomulco Valley	LLOVIA	49,400	Rainfall	luvirol, planosol, feozem	Hillsides and mounds	Between 2500 and 2600 m
		200	Irrigation			
Mounds and small valleys north ride	LOVAN	42,167	Rainfall and reduced areas of residual humidity	feozem, vertisol, planosol, andsol	Mounds and small	Around 2600 m

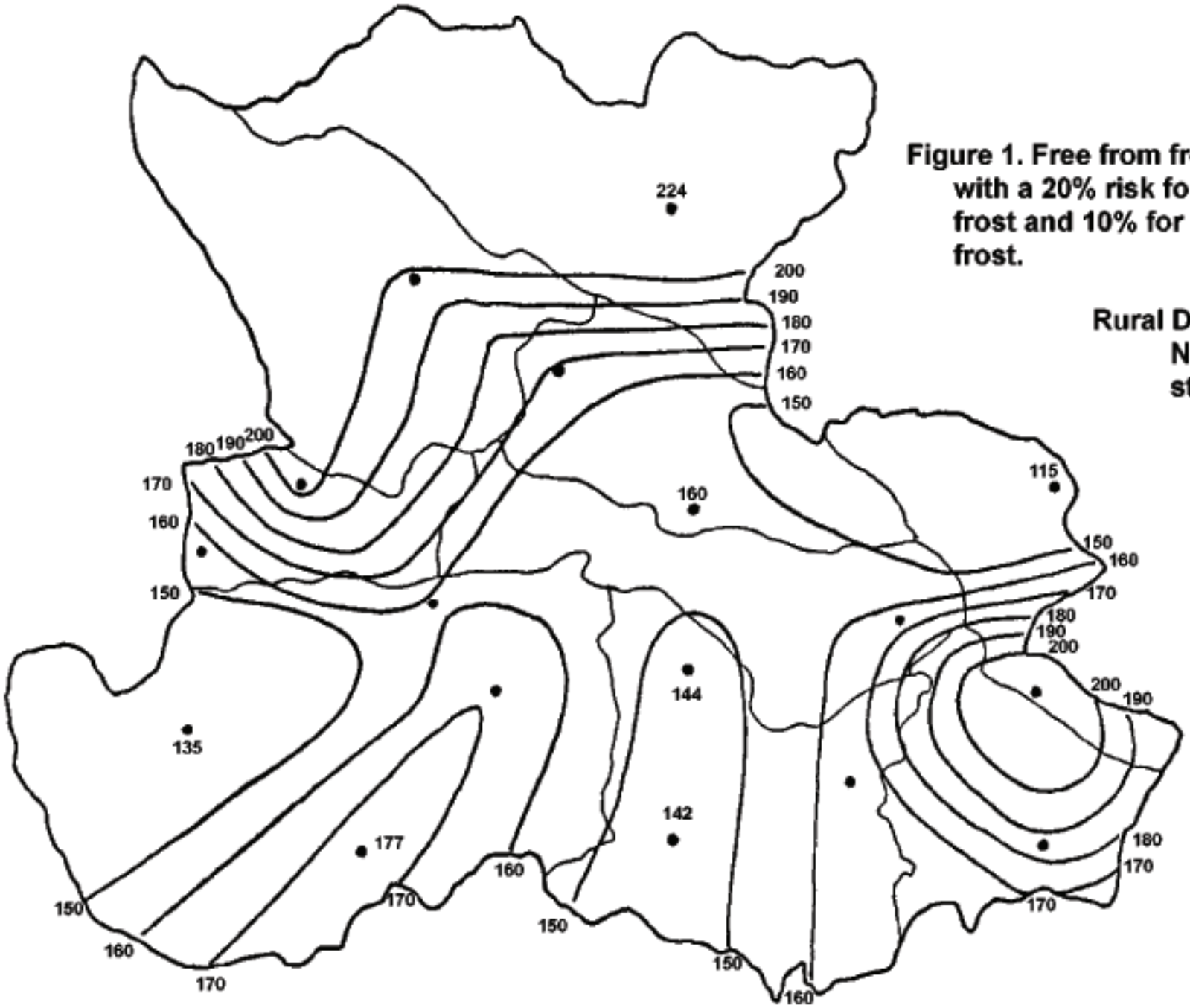


Figure 1. Free from fronst days with a 20% risk for latest frost and 10% for foremost frost.

Rural Development District Number 68. Atlscomulo, state of Mexico.

● weather station

—— country boundary

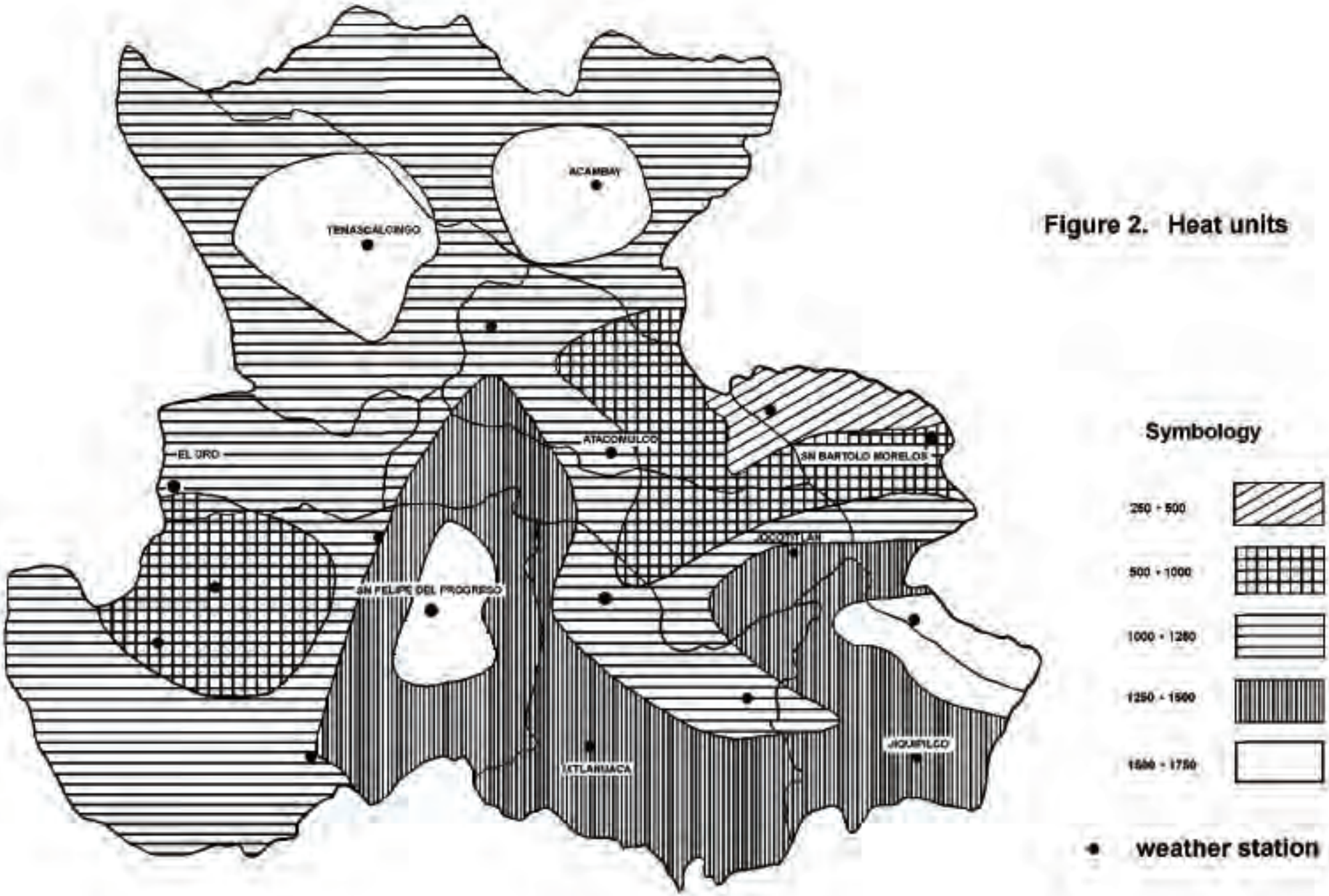


Figure 2. Heat units

Fig. 3. Pluvial precipitation to 80% probability (mm.)

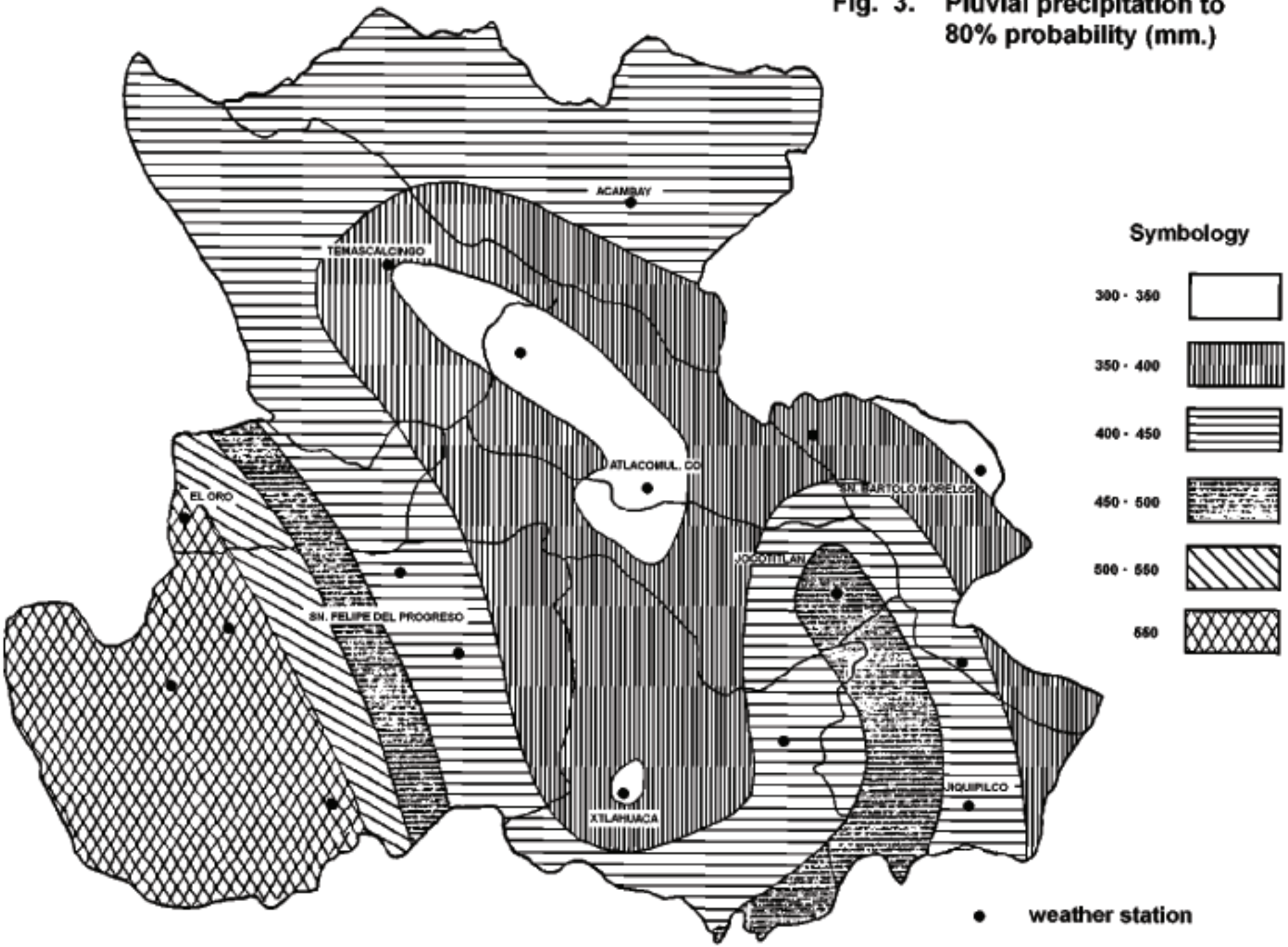


Fig. 5. - Simplified Scheme of the Family Production System.

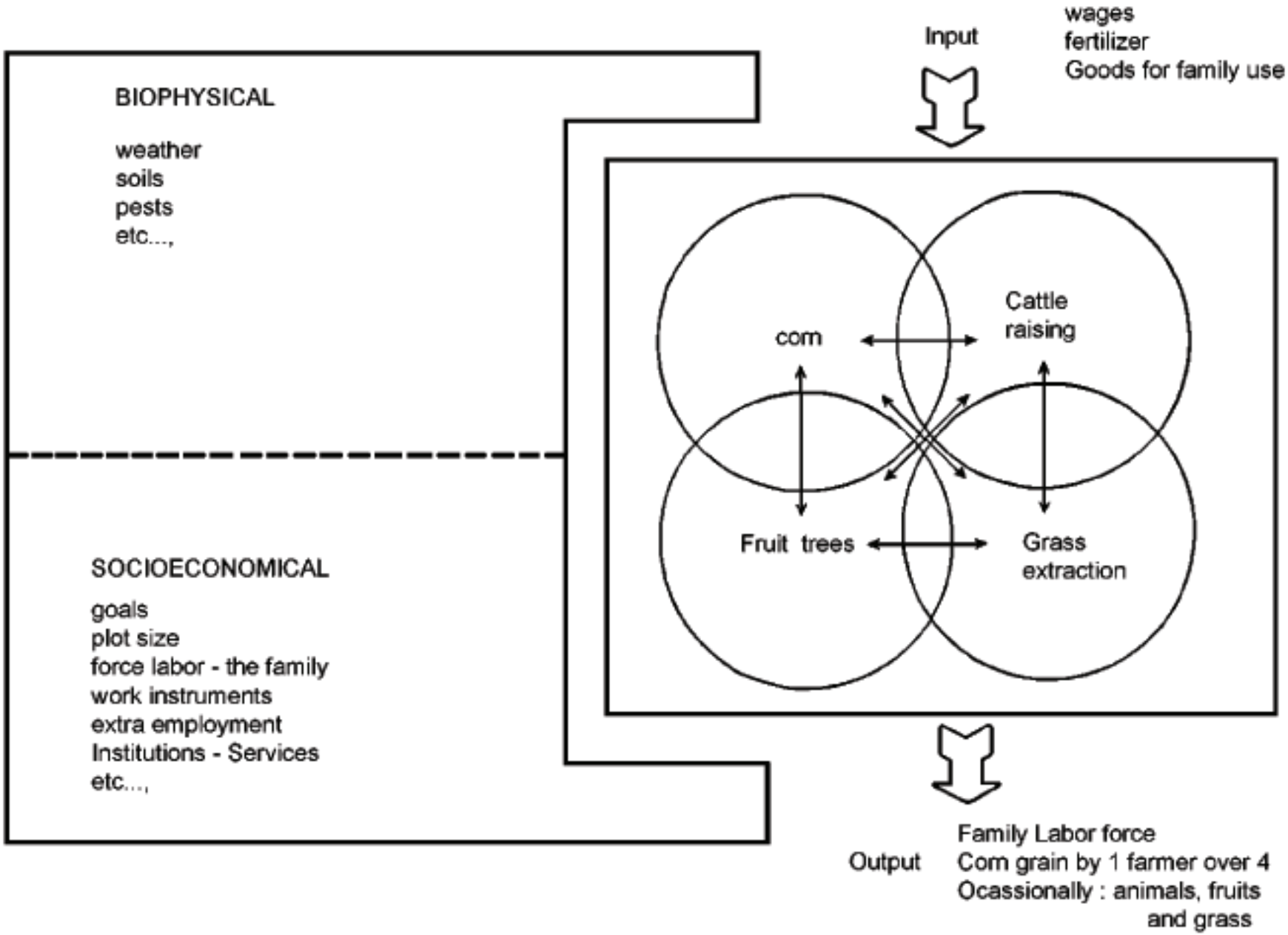
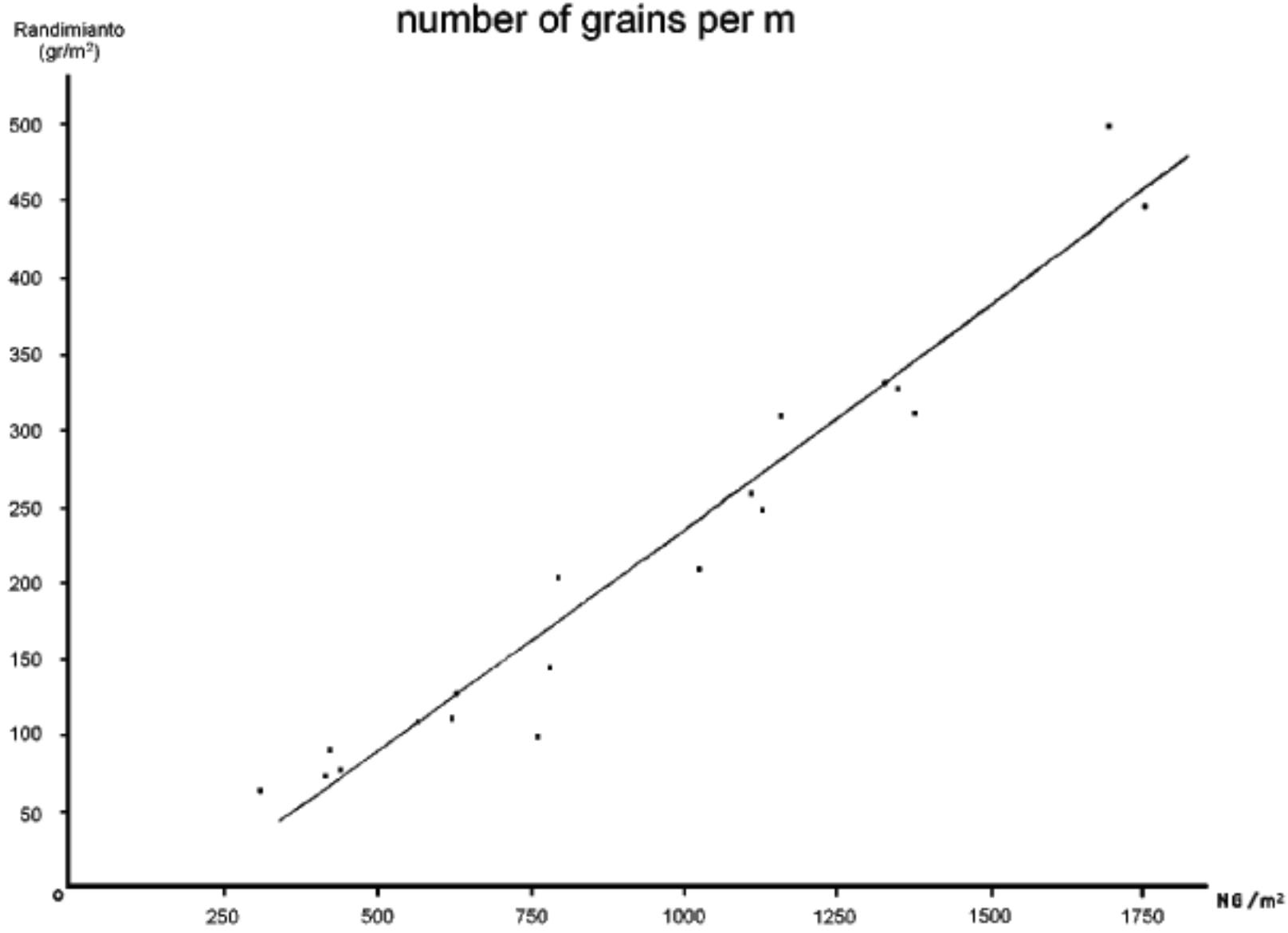


Fig. A. Evolution of grain yield of a function of number of grains per m



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CROP FARMING SYSTEM CONSTRAINTS IN TRANSKEI : IMPLICATIONS FOR RESEARCH AND EXTENSION*

T.J. Bembridge**

INTRODUCTION

The task of stimulating and improving the output of small-scale farmers in Southern Africa is indeed a formidable one. The pattern of agricultural development that emerges in a country will depend on interactions between its policies, administrative capacity, institutions, physical resources, the nature of technology and the all important human potential (Hunter, 1974).

Farming systems research (FSR) originally developed in response to the fact that limited resource small-scale farmers were not adopting improved technology generated by traditional research and diffused by extension services. The standard approach to FSR is normally a description of the farming system, design and testing of technology, followed by verification on the farm, and finally extension inputs to achieve widespread adoption of suitable technology.

It is now widely accepted that the farming system is influenced by a set of determinants which in turn can be influenced by the operation of the farming system itself. If the determinants change, then so, to a greater or lesser extent, does the farming system. FSR has grown to the point where there is no one ideal method, but rather a number of alternative methods designed for different purposes, environments and circumstances (Maxwell, 1986).

Farming Systems Research procedure normally involves five steps, namely: 1) problem identification, 2) diagnosis of constraints, 3) making recommendations, 4) implementation, and 5) evaluation of the programme (Norman, 1980, p. 7). This paper focuses on the first three steps of the procedure, with special reference to crop farming systems in Transkei. It should be born in mind that FSR is a continuous and dynamic process; the time span for implementation may involve a period of 10 - 15 years (Maxwell, 1986, p. 67).

In order to orientate the reader, this paper first summarizes agricultural production trends in Transkei and the various farming system determinants and their constraints to farming systems in the study areas. The main focus of the second part of the paper is on empirical results which analyze the constraints in the crop farming system with special reference to maize production. The final section discusses the implication of the findings for research and extension.

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*This paper is based on data from a Ph.D. thesis, University of Stellenbosch.

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BACK ROUND TO THE STUDY

Location

Transkei, as it is known today, came into existence as a result of a series of British annexations into the Cape Colony between 1879 and 1894.

Transkei has a total area of some 4 379 000 ha and is situated between 27° and 30° east and 30° and 37° south, in the south-east of Southern Africa. It is bordered by the Indian Ocean in the south-east (Fig 1).

Ethnic group

The Xhosa-speaking people of Transkei arose historically from a larger group known as the Nguni, to which the Zulus and Swazis are also affiliated (Wilson, 1969). The Xhosa are divided into about ten tribal clusters, each with its own history and culture.

The Agricultural Potential

In terms of climate, soils, vegetation and other agro-ecological factors, Transkei has a high and diversified agricultural potential which has been well documented (van Wyk, 1967; Woods and van School, 1975; Hawkins Associates, 1980). Approximately 46 per cent of the country is suitable for intensive crop and livestock production, with 16 per cent of the lower rainfall areas suitable for semi-extensive livestock production supported by drought resistant fodder and grain crops. There is also a fairly high irrigation potential for both large-scale and small-scale irrigation.

The Environmental Situation

Field observations by the writer, to examine farming standards and land-use both in the study areas and in the country as a whole, indicated gross soil erosion of arable land and grazing in many areas. Soil erosion is definitely depressing crop yields. Already part of the arable potential in some areas is being damaged to the extent that its cropping potential has declined, and progressive deterioration is taking place on a proportion of the remainder of cultivated land and much of the grazing areas. Furthermore, the best arable land is not always being used (Bembridge, 1984).

Agricultural Production

Investigations by the writer have revealed that any assessment of present productivity and agricultural output in Transkei has to contend with unreliability of estimates and statistics. This applies particularly to crop production. Livestock data tend to be more reliable. Nevertheless, a number of general trends and conclusions are justified on existing data.

Table 2. Carrying capacity of cultivated land by area.

Area	Present Cultivated Area ha	Yield Potential Tons/ha	Estimated Population	Estimated Subsistence Carrying Capacity	Surplus Carrying Capacity
Qamata	2 085	7,0	11 149	55 044	43 895
Emgcwe	2 062	2,5	3 180	19 444	16 264
Qumbu	5 449	3,5	9 463	71 956	62 283
Total	9 596	13,0	23 792	146 414	122 442

households who had land rights. The sample size varied from 10,0 to 20,0 percent, depending on the area population. The distribution of the sample frequencies for maize practice adoption scores closely approximated symmetry, and it was significant on a goodness-of-fit test.

FARMING SYSTEM DETERMINANTS

Before discussing crop farming systems it is necessary to briefly outline farmer circumstances and environment in terms of the agro-ecology of the study areas, various institutional factors, the economic environment and farmer characteristics, all of which have a direct or indirect effect on farmer decision making (Byerlee and Collinson, 1984, pp 8 - 10).

Table 1 summarizes the more important problems which need to be tackled on a planned priority basis. The results illustrate the interrelationship of the various determinants of farming systems. Suggested solutions illustrate that most of the constraints identified are subject to change in the medium to long term (5 - 15 years).

AGRO-ECOLOGY OF THE STUDY AREAS

Various types of farming systems have emerged in Transkei after long processes of trial-and-error experience in an endeavor to fulfill the compelling necessity of basic needs within the constraints of the prevailing socio-cultural and political milieu.

It is not within the scope of this paper to give a detailed description of the physical environment of Transkei or of the survey area. This has been well documented by other researchers (van Wyk, 1967; Wood and van Schoor, 1976; Hawkins Associates, 1980). What follows is a brief summary in order to orientate the reader.

Agro-ecological Areas

Hawkins Associates (1980) delineate the country into 4 agro-ecological units based on potential levels of farming intensity according to rainfall (Fig. 3). According to this classification both Qumbu and Emgcwe fall within the semi-intensive crop and livestock production area. Qamata falls within the area suitable for semi-extensive livestock production supported by limited drought resistant crops. However, because of available irrigation, the area is well suited to intensive crop production. In short, all three areas of investigation have a good potential for maize and other food crops, as well as cattle and small-stock production.

Production potential

The survey showed that the average household had 6,02 members. Using the standards of Fox (1966) and family composition data from the survey it can be computed that the average minimum nutritional requirements for full subsistence requirements for each individual in the household is 2 324 calories per day. Consequently it can be

computed that the average person requires 848 260 calories per annum. On this basis and using estimates of potential maize yields and calories per hectare from the survey areas (Marais, 1979), Table 2 shows that on average the three areas have the potential to provide the grain subsistence requirements for more than six times the present de facto population. On a national basis, then, assuming a conservative potential yield of 1 500 kg/ha from the present cultivated area, Transkei could be self sufficient in maize production.

Rainfall

The mean annual rainfall in Qumbu varies from 650 to 900 mm, 70 per cent of which falls within the summer months. Emgcwe has a slightly lower mean annual rainfall of 704 mm, 75 percent of which falls in the summer period. Water budgets calculated for the area suggest fairly favorable soil moisture regimes with good potential for dry land maize.

Rainfall at Qamata averages approximately 500 mm, but is extremely variable. Rains are largely in the form of thunderstorms during the months of October to March. Winter rain can be regarded as largely ineffective.

Temperature

Mean monthly temperatures in Qumbu and Emgcwe vary with altitude. In the summer months of December to March, temperatures average between 18,8 and 21,1°C, and between 11,3 and 13,6 C in winter. Widespread frosts occur throughout the area from June to August.

Qamata is hotter than Emgcwe and Qumbu, with summer maximums varying from 23°C in September to 29°C during the period December to February, while in June and July maximum temperatures are 18° - 19°C. Frosts occur from the end of May to early September.

Soils

Hutton Form soils, reddish and varying from shallow to deep and from light to heavy texture are predominant in Qumbu. Most cultivated areas have been cropped for a long time and are generally low in organic matter and phosphorus. Severe erosion has occurred and many of the lands have steep slopes. Nevertheless the area has good cropping potential if the nutrient deficiencies, particularly phosphorus, are corrected.

Soils in Emgcwe are not as good as in Qumbu and many lands are steeply sloping. In much of the present cultivated area the soils are shallow, and in recent years have been severely eroded. Yields are poor, particularly in the shallow eroded soils, due to continuous cropping, nutrient depletion, poor physical soil condition and poor soil conservation layout. There are, however, large areas presently under grazing that would be suitable for crop production. As in the Qumbu area, parts of Emgcwe have a reasonably good cropping potential, provided soil nutrient deficiencies are corrected.

At Qamata, irrigable soils are of alluvial origin, varying from light to medium textured nearer the Indwe river to heavy textured along the Qamata river. The surrounding hill slope areas are commonly stony and have rock outcrops. Skeletal soils are dominant. The soils are considered suitable for intensive irrigation.

Water Resources

The Qumbu area is dissected by perennial rivers which run from north to south. Surface run-off is high, and with adequate conservation most of the larger tributaries of the rivers would have a good sustained flow. Because of soil availability and suitability, topography and other factors, there is no real potential for large scale irrigation in the area (Loxton, Hunting and Associates, 1978). There is, however, a potential for the development of a number of small-scale schemes commanded by earth dams.

Emgcwe is dissected by the Emgcwe river. Surface run-off is high, and under adequate conservation most streams of this area would have a good flow. However, because of erosion, flow has become erratic and silt loads high, so that there is the danger of perennial flows becoming less certain. Small-scale gravity irrigation schemes are possible along the main stream. At Qamata irrigation scheme water is supplied by gravity canal, and thence by subsidiary canals to 17 night storage dams. Domestic water supplies in all areas were found to be unsatisfactory.

Grazing areas

Although the potential grazing carrying capacity in Qumbu and Emgcwe is potentially very high, the nutritional state of the grazing is insufficient to maintain body mass without a protein supplement. In Qamata the nutritional status of the grazing is reasonably good. However, the area is severely overgrazed and in a deteriorated state.

Conclusion on agricultural potential

The potential of the survey areas of Qumbu and Emgcwe are considered to be reasonably representative of the semi-intensive agriculture which typifies about four-fifths of the country, while Qamata is typical of the irrigation resources in the drier western part of the country. Unfortunately these vast resources are deteriorating and are being utilized at only a fraction of the potential because of various institutional, technological, socio-psychological and socio-economic constraints which are discussed in this paper. A general conclusion was that resource endowment is not a constraint to agricultural development. New approaches to land utilization must be based on the concept of sustained, ecologically sound development.

INSTITUTIONAL FACTORS

As a result of Government policy known as 'betterment planning', rural infrastructural development, although inadequate, is not unreasonably poor compared to other less developed countries in Africa.

An operational policy and strategy for the development of agriculture in rural Transkei has, by and large, still to be formulated. Provision of credit and suitable marketing was found to be singularly lacking.

Under the land tenure system in Transkei arable land is allocated to an individual by the tribal authority and cannot be subdivided, consolidated or sold. Grazing land is communally owned. Although this factor together with the preponderance of non viable farming units is an undoubted constraint, findings showed that less than half of the respondents aspired to possessing more land.

Since Transkei has no research station of its own, the agricultural research system was generally based on research aimed at commercial farmers in South Africa. Such research tends to be based on the maximization of yields and income and does not necessarily meet the needs and circumstances of small-scale farmers.

An in-depth study of the extension system showed that the extension service was neither effective or efficient. The extension service has operated haphazardly with neither priorities or plans, with the result that its objectives have not been achieved. There were considerable deficiencies in technical support and administrative controls at all levels. There were also shortcomings in the quality of staff, especially at field level. Low levels of farming efficiency can to a large extent be attributed to inaccessibility of relevant farming information as well as to low contact with information sources.

Farmers in Transkei have been operating in a difficult environment, in the sense that none of the institutional requirements and supporting services necessary for successful agricultural development have been adequately fulfilled (Table 1).

THE HUMAN POTENTIAL

In order to develop appropriate technology it is necessary to have a good understanding of farm households and their decision making. The typical Transkei households earn most of their income (±90%) from non-farm sources. It was found that in terms of income distribution and levels of nutrition, approximately 40 percent of rural families are living in a state of abject poverty.

It was found that due to labor migration of male heads of households, 60 percent of de facto heads of households were females, and that 25 percent of them were widowed or divorced. Evidence from the study suggests that institutional and environmental constraints provide little incentive or motivation for able bodied males with entrepreneurial ability to remain on and farm in the rural areas. The average family size was approximately 6 persons and one-third of heads of households were illiterate.

Because of the absence of able-bodied men in the productive age groups, the labor burden of producing food (85%) and vegetable crops (79%), pigs (86%), poultry (86%) and also to a lesser degree cattle

and small stock (30%) is borne by rural women. Since women have the additional burden of providing water and fuel and undertaking general care of the family, shortage of labor for agricultural activities is a definite constraint for the adoption of a better technology for improving agriculture. Paradoxically, despite shortages of labor at peak periods, the average farm holding in Transkei cannot provide fulltime employment for able-bodied males.

It was found that there is a lack of adequate social structure and little formal organization at village level which could effectively facilitate local discussion of problems, the purchase and organization of farming inputs, or the sale of products. This is a major constraint to development of the rural areas.

Sixty-two per cent of respondents were found to have very poor managerial aptitude and would probably be unable to integrate modern principles and technology fully into their farming systems. Twenty six per cent were found to have 'poor' managerial aptitude and twelve percent can at best be described as 'fair' with potential of becoming progressive farmers. Farmers were particularly weak in the financial and labor aspects of management. Farmers generally had overoptimistic perceptions of soil fertility and condition of grazing areas.

Farm decision making is largely influenced by the presence or absence of the husband. Although there is a grey area of uncertainty about the finer details of family decision making, it was found that farmers' wives were largely responsible for day-to-day decisions on crops (72%), vegetables (73%), pigs (85%), and poultry (86%) as well as to a lesser extent for cattle (47%) and sheep and goats (49%).

In line with the findings on poverty in terms of income levels and diet, while the majority of respondents (74%) felt crop yields could be improved, only 42 per cent were positively motivated to improve their quality of life. Only 35 per cent had a positive attitude to cooperating in crop improvement schemes.

It was found that both felt and unfelt basic needs which require to be met include improved quality of diet, clean drinking water, improved housing, household consumer goods, health services, education, adult education, appropriate village level technology (e.g. fuel and water supplies), improved infrastructure and participation in decision making. Some of these needs are of course inter-related.

Evidence from the study showed that, in practice, rural families do not all share common objectives, perceptions, attitudes and motivation regarding basic needs, standard of living and well being.

CROP FARMING SYSTEMS

Thus far the determinants of farming systems and the environment in which the farmer finds himself have been discussed. Equally important is qualitative information to throw some light on constraints in the crop farming system.

Arable Land Holdings

On the assumption that approximately 4 ha of dry land arable land is required for subsistence-level farming in medium to high potential agro-ecological areas, it was found that 92 per cent of respondents have non-viable farming units which is a clear disincentive to full-time farming.

Adoption of Maize Production Practices

There has been comparatively little research done on adoption of innovations in less developed countries, especially in Southern Africa. While data showing how individuals go about adopting an innovation may be interesting, such information is useful only to the extent that it contributes to the knowledge of why individuals accept and integrate practices into their farming systems. Although this study is specifically concerned with the extent and rate of adoption, it must be borne in mind that adoption is a process.

Successful maize production is a complex phenomenon, and many factors can and do cause variations in yields (Mohr, 1975). Maize practices evaluated in the study have been recommended by extension and research over the past 15 to 20 years, ensuring a reasonable time for respondents to pass through the adoption process for each innovation. The practices studied are all considered necessary by professional agronomists for efficient maize production, and cover the whole production process from land preparation to harvesting.

In this study innovativeness was measured by an adoption scale with individual practices in relation to yield. For example, weed control was given a higher weighting than stalk borer control. Although using adoption of innovations as a measure of extension effectiveness has limitations in that it does not measure economic production, it is nevertheless a good measure of extension impact (Bembridge, 1979).

Buildings, implements and farming tools

Adequate basic storage facilities, implements and tools are essential pre-requisites for efficient crop production. There was a general lack of farm storage facilities, implements and garden tools. For example, only one third of farmers possessed an ox drawn plough, 22 per cent an ox planter, 30 per cent an ox cultivator and 10 per cent a harrow.

A shortage of ox-drawn cultivators as well as draught animals was found to be a major cause of poor weed control. The lack of harrows to control early weed growth is also a constraint. Lack of ox-drawn planters, which are usually inefficiently operated, results in many farmers resorting to the unsatisfactory method of hand planting behind the plough, with resultant poor plant populations. It was found that only 37 per cent of crop farmers possessed any cattle.

The general low percentage of farmers possessing garden tools can be regarded as a direct reflection of the low yields obtained from

vegetable gardens. Only about one in five farmers (21%) has adequate shelter for farm implements, lack of which inevitably results in the deterioration of implements if they are exposed to the elements.

A general lack of the means of cartage of farm requisites by half of the respondents (49%) is a major constraint to the application of kraal manure on maize lands. Almost half (46%) of those who had some form of cartage used sledges, which are a definite erosion hazard.

Maize growing practices

Figure 4 shows the overall percentage of farmers adopting recommended practices in the study area. There were significant differences between areas in adoption of certain practices. It is not only important to know whether a practice was adopted or not but more important how it was adopted.

- Only 17 per cent of farmers practice autumn ploughing. All ploughing at Qamata is carried out by Government tractors, whereas at Emgcwe, 83% of the ploughing is done by oxen and the remainder by hired tractor. In Qumbu 74 per cent of ploughing is carried out by hired Government tractor and the rest with oxen. Of those who carried out ploughing by means of oxen (28%), three in four used 6 oxen, and the remainder 4 oxen. Whatever draught power is used, there are practical problems as regards timely ploughing, either because oxen are not in good enough condition, or because Government tractors are not available at the right time.
- Approximately half of the respondents (48%) did not plant at the recommended time before the end of November (Fig 4). Even at Qamata, where season length is important to achieve optimum yields, only two in five farmers (42%) planted early.
- At Qamata most planting is done by hand behind the plough, Whereas in Qumbu and Emgcwe the vast majority of farmers used ox-drawn planters, which in most cases do not operate efficiently, as is evidenced by the generally low plant populations (Fig. 4). Hand planting using hoes, which is the most satisfactory method of achieving good stands is seldom practiced. Due to the availability of Government tractors, harrowing before planting to control initial weed growth is practiced to any great extent only at Qamata (Fig. 4).
- Although one in four farmers (26,1%) used kraal manure on their lands, application per ha was extremely low. Sixty-five per cent applied less than half a ton per ha and only 11 per cent applied more than one ton per ha. Manure is often applied with the planter, which allows only for small quantities to be applied.
- Similarly, of the 48 per cent of respondents who used fertilizer, four in five (82%) used less than 200 kg per ha, which is the standard recommendation of the agricultural department, and in many instances (58%) applications were so low as to be insignificant. Only one per cent top dressed maize with nitrogen (Fig 4). The most frequently cited reason for not using fertilizer was 'lack of money'.

- Only one in four of respondents (27,9%) used seed of Recommended varieties, the majority using their own selected seed (Fig. 4). At Qamata, a greater number used improved seed, probably because of the greater likelihood of a response to improved varieties under irrigation. Because of the generally low adoption levels of other cultural practices, the majority of farmers are, in any event, not likely to get a significant response to the use of improved varieties, particularly hybrids.

- Although the incidence of cutworm varies according to seasonalconditions, cutworm outbreaks can seriously affect plant populations. Only four per cent of farmers adopted cut worm control practices (Fig 4).

- On the basis of optimum plant populations for approximately 1m rows of 40,000 for irrigated maize and between 20,000 and 30,000 plants per hectare for dry land maize, average plant Populations were less than 50 per cent of recommendations, and the coefficient of uniformity was also less than 50 per cent (Fig. 4). Therefore low plant populations are a major cause of low yields.

- The maize stalk borer is the most important pest attacking Maize in South Africa. Of the three in ten farmers (29%) who Controlled stalk borer, only 12 per cent were observed to be carrying out complete and thorough control.

- Fig 4 shows that lack of proper weed control is a major constraint to maize production. Weed control was poor in all areas in the first 40 - 60 days after planting, with only about one in two farmers controlling weeds adequately during this stage. A similar picture was apparent in the later stage of the crop. The low levels of weed control, particularly in Qamata, can be partly attributed to the heavy reliance on hand weeding.

- Although almost half of respondents (47%) said they practiced Crop rotation, only about 4 per cent rotated crops on a sound basis, with a legume crop following maize. The high apparent adoption rate under irrigation in Qamata (Fig 4) is due to the fact that many farmers there are able to follow maize with a winter crop, usually wheat.

- Inter-cropping or multiple cropping describes forms of Cropping practices where total production from a unit area of land is achieved by growing crops simultaneously. Despite the fact that this practice is not recommended by extension workers, intercropping of maize with beans and pumpkins is widely practiced throughout Transkei. While practiced to a significantly lesser extent under irrigation in Qamata (35%), intercropping was practiced by four out of five farmers (77%) in the dry land areas (Fig. 4). Although spacing and patterns and methods of inter-planting vary widely, field observations showed fairly high populations of pumpkins and beans. It was not possible to obtain accurate figures for yields from inter-cropping, but observations indicate yields of both pumpkins and beans were low. Competition may reduce potential yields of both the main crop and interplanted crops. Poor weed control is an added constraint.

- The general impression gained during numerous visits to the Qamata irrigation project was one of poor motivation, low standards of production, inefficient irrigation, and lack of routine and attention to detail. The scheme management does not assume a strong position towards farmers. Farmers do not fulfill such duties as planting at the right time, weed control and irrigation according to schedules.

- It was found that three in ten farmers (31,4%) at Qamata did not irrigate at all, and a further 43.7 per cent did not apply sufficient water during critical growth periods to achieve optimum yields. Therefore, in 75 per cent of cases, insufficient irrigation is a major cause of low yields. This was not due to unavailability of irrigation water, but rather to poor management and organization of water allocations and distribution. Poor irrigation techniques often resulted in applying excessive water.

Rate of adoption of selected maize practices

The stage in the adoption process of a practice can be assessed by obtaining the data of first adoption of that practice by the population. Fig. 5 shows the cumulative percentages of farmers adopting three important practices over the past decade.

Although use of fertilizer has shown a steady increase over the past 10 years, with over 90 per cent of respondents having adopted the practice at some stage or another, the present level of adoption is less than fifty per cent (48,0%) (Fig. 5), Rejection of this practice by 48 per cent of those who tried it can be attributed to lack of response caused by low fertilizer application rates. Increased cost of fertilizer has probably also been a factor.

The trends for adoption of improved seed and stalk borer control have not been as spectacular as for fertilizer (Fig. 5). A similar pattern of rejection was observed with 42 and 30 per cent respectively rejecting these practices, probably for similar reasons.

These findings suggest that adoption of a recommended practice or practices has not resulted in a positive economic yield response. Of greater importance than adoption per se is how the practices are applied - deficiencies in application were observed in all three practices. Results suggest that it is possible that farmers do not perceive the inter-relatedness of practices in the farming system. In short, adoption curves in Fig. 5 hide the fact that a large percentage of respondents subsequently rejected practices after adoption, and that application of technology was unsatisfactory.

Knowledge of Practices

The advantage of winter ploughing was realized by three in five respondents (61,2%). Of these, only one-third perceived the advantage of moisture conservation. Others perceived the indirect advantages of early planting (20%) and high yields (46%), which suggests that in two-thirds of the cases extension has not been successful in getting

the message of moisture conservation across to farmers. The small percentage (17,8%) who saw an advantage in crop rotation perceived it as a "good farming" practice, but few (9%) perceived, for example, the advantage of leguminous crops in a rotation.

Although the vast majority of farmers were aware of fertilizer and maize stalk borer control practices, their knowledge of the scientific application and inter-relatedness of these with other practices was generally lacking.

These findings suggest that the majority of respondents were aware of practices, but did not have full knowledge of the proper application of the innovation.

Inter-relationship of Practices

The inter-relationship of the adoption of important maize practices and their effect on yield is shown in Fig. 6. It can be concluded that there are considerable differences in the rates at which individual practices are adopted by farmers.

Some practices seem to be related in the sense that a farmer tends to adopt all or none, while other practices seem to be adopted relatively independently. In general, farmers had no clear concept that all practices are not only inter-related, but inter-related in a definite pattern and direction. This finding explains why many all-inclusive cropping package programs in Southern Africa have been unsuccessful.

In a step-wise multiple regression model, in which maize yield was entered as a dependent variable on the 10 maize practices as independent variables, the total regression model was significant ($P<0,01$) with a coefficient of determination of 23,94 per cent. The low percentage of variance explained suggests other non-biological factors may contribute to low yields (Refer Fig. 9). The most important variables explaining the 21,96 percent of the variation in yield suggest that farmers who used improved seed were also likely to use fertilizer, control insects and plant at the correct time.

Factors Influencing Adoption of Practices

Factors influencing farmers' innovativeness, expressed as the overall adoption rate of maize practices, is shown in Fig. 7. A farmer's resources in terms of available arable land and implements, as well as various socio-psychological characteristics such as age (negative), knowledge, managerial aptitude, attitudes and extension contact, all have an influence on adoption of technology, which in turn leads to higher yields and production, improved living standards and health. It can be concluded therefore, that innovativeness is a multi-variant cause-effect phenomenon.

In a step-wise multiple regression model, in which adoption of maize practices was entered as a dependent variable on 42 independent socio-economic, socio-psychological and other variables, the total regression model was significant ($P<0,01$) with a coefficient of

determination of 23,74 per cent. Knowledge of crops was the most important variable determining adoption of maize practices, which emphasizes the importance of agricultural extension in providing the necessary knowledge. The importance of resources is illustrated by the relationship found of size of land, total maize yield and amount of food produced with practice adoption rate. More progressive farmers had more favorable attitudes to land reform, betterment, and co-operation with crop improvement schemes, and tended to participate more in local organizations.

Maize Yields

Because of the unreliability of statistical information on maize yields, it was decided for the purposes of this study to estimate yields by sampling. Depending upon the size of the land, at least six random samples of 10m row length were taken in each respondent's land. Yield per hectare was calculated by harvesting and weighing shelled and unshelled cobs from the sample area, and by estimating the number of plants per hectare. Allowance was made for cobs or plants harvested as green mealies (Marais, 1978; Deboeck and Kinsey, 1980, p.30).

The in-field yield per hectare in the three survey areas averaged 914 kg/ha at Qamata, 328 kg/ha at Emgcwe and 181 kg/ha at Qumbu (Fig. 8). The extremely low yield levels are a direct reflection of the low rate of adoption of modern technology. Only about 5 per cent of farmers are achieving anywhere near acceptable yields of 2 tons per hectare.

Maize Yield Constraints

The constraints to maize yields are conceptualized in Fig. 9. This model recognizes that due to non-transferable technology and environmental differences, there will always be differences in yield between research stations and best farmer yields (Yield Gap 1), and that the existing gap (Yield Gap 2) between farmer yields and best potential yields is caused by both biological constraints, in the sense of non-application or poor application of technology, and by socio-economic constraints which prevent farmers from using the recommended technology (Dillon and Hardaker, 1980).

Some researchers have been able to quantify the size of the yield gap and deduce how much of it is caused by biological and socio-economic constraints (De Datta et al., 1978; Gomez, 1977). In this study it was possible only to conceptualize the constraints in terms of available data. Data obtained suggest socio-economic problems may be greater than biological constraints.

In a step-wise regression analysis in which maize yield was entered as a dependent variable on 42 independent socio-economic, socio-psychological and other variables, the total regression model was significant ($P<0,01$) with a coefficient of determination of 58,13 per cent. The findings that total maize crop harvested was the most important variable explaining yield, suggests that those farmers with more resources in the form of land and implements were the most efficient farmers. They also had greater contact with extension and

other media, a higher level of managerial aptitude and a favorable attitude towards co-operating in extension programmes.

Farmers' Perceptions of Maize Production

The phenomenon of droughts, even under irrigation conditions at Qamata, was cited as a major cause of low crop yields by one in five respondents. Quite correctly, farmers in Emgcwe, which is more marginal for maize, perceived droughts as a greater hazard than in the other areas. Despite the overall low level of adoption of maize production practices, only 28 per cent of farmers perceived poor methods as a major reason for poor yields. This finding has important implications for future extension programmes. Almost half of the farmers (48%) gave the valid reason, namely lack of finance, and the related problem of lack of farming equipment, as the major reason for low yields, indicating the need for short term credit to be made available.

On being questioned about their own personal needs for crop production, 70 per cent of respondents cited finance or inputs such as implements, seed and fertilizer which require finance, as their needs to achieve higher yields. One in five (19%) said they needed 'better land'. On being questioned as to why they felt some farmers were achieving better yields than themselves, half of respondents (50%) felt that their fellow farmers had ' more money', while others felt they had 'better land' (12%). Only two in five (38,6%) accepted 'better management' as a reason.

The fact that four out of five (79%) of farmers felt they could achieve higher yields suggests considerable scope for extension programmes supported by the necessary inputs and infrastructure. At Qamata, where none of the producers are achieving anything near potential production, three-fifths of farmers (62%) were not satisfied with their production levels, which suggests considerable scope for improving production, but at the same time indicates that about two in five farmers are not motivated to improve their levels of production.

Gross Value of Crop Production

Gross value of crop, vegetable and fruit production was calculated using producer prices in South Africa (Republic of South Africa, 1980). The extremely low levels of production shown in Table 3 are a direct reflection of the low rate of adoption of modern technology. Gross income from crops was higher in Qamata due to winter cropping with wheat. Beans are second in importance to maize and provide a valuable source of protein.

Despite having a lower potential, production in Emgcwe was higher than in Qumbu. Although home gardens have considerable potential for providing a valuable supplement to the diet, the production of vegetables and fruit makes an insignificant contribution to household consumption (Schere, 1969, p. 212).

Half of the respondents achieved a gross return of less than R30 from crops and home gardens, and less than 10 per cent had a return of more than R100.

Gross Margin from Crop Production

Gross margin was calculated using standard fertilizer costs, seed costs (if purchased) and actual tractor hire costs. Since labor is usually provided by the family unit, and also because there are difficulties in valuing labor inputs, this factor was not included in the analysis. In the dry land areas of Qumbu and Emgcwe there was on average a loss on crop production, while Qamata irrigation scheme showed a gross margin of R91,93, as against the overall margin for all areas of Rll,47. Half of the respondents showed a net loss from crop production, with a significantly higher (P<0,01) proportion of losses in Qumbu and Emgcwe respectively, than in Qamata.

IMPLICATIONS FOR RESEARCH AMD EXTENSION

Evidence from this study suggest that institutional socio-cultural and socio-economic factors are as significant as biological factors in farmer response to agricultural innovations.

Small farmers in Transkei are not necessarily un-productive because they are allocating resources inefficiently, but because they are caught up in a vicious circle of lack of land, capital, inputs, credit, appropriate policies, information, technology and marketing facilities. The early history of peasant farming in Transkei suggests that, provided opportunities and resources are available, the small-scale farmer will respond, often quite dramatically, to appropriate technology and agricultural production incentives.

Institutional factors

Solutions to the multiplicity of agricultural development problems highlighted in this paper emphasize that plans need to be formulated at local, regional and national level, through a coordinated, interdisciplinary team effort. This approach implies development of local village organizations to participate as far as possible in local planning and decision making.

Probably more in keeping with the present land tenure system in Transkei of occupation rights for arable areas, and communal use in the grazing areas, would be a system of negotiable rights for arable land, coupled with grazing rights registered and administered by local authorities. This would provide some incentive for bona fide farmers to acquire adequate land resources.

A realistic view of political constraints on decision making emphasizes that it is probably only possible to make progress in a piecemeal fashion. Political constraints are likely to be less binding on decisions related to the goal of expanding agricultural production by means of acceptable technology.

This study has shown clearly that the acquisition of relevant knowledge is a necessary and important requisite to agricultural change. It follows that agricultural development stems from effective agricultural extension strategies. Extension must be orientated towards both needs and means. In this context, there seems to be a strong argument in favor of reorientating and reorganizing extension services with a view to combining the responsibility for providing relevant information with the responsibility for savings and credit schemes, supply of inputs, and involvement in marketing.

Based on the human potential, as well as on agricultural production data, it can be concluded that agricultural development is a process in which not everyone participates at the same rate. Farmers vary in their knowledge, receptivity to new innovations and in their resources. A small proportion of individuals have the necessary knowledge and managerial aptitude and knowledge to take advantage of high technology innovations. A second group (the 'middle majority') have the latent ability and potential, and are able, with the assistance of extension, research and other supporting services to progress over time to a level of efficiency achieved by the more progressive farmers. Members of the third group are prevented by a combination of personal, socio-economic and structural constraints from becoming progressive agricultural producers; they nevertheless have some potential for improving their socio-economic situation through provision of basic needs.

In the writer's view, extension efforts will have the highest potential effectiveness on the community as a whole if they are concentrated on target groups in the "middle majority" category. The more progressive farmers will still require some guidance and assistance, while the disadvantaged group require a special programme suited to their ability and resources. Technology must be sound, economic, practical and appropriate for each target group. The study has shown the importance that the extension 'message' stresses the operational use of farming practices and the dependence of one practice on another.

Most of the crops and 'improved practices' recommended are, at present, the results of agricultural research outside Transkei. It would seem logical now to start a more realistic on-the-spot testing and modification of technology using the FSR approach in order to ensure that extension workers have a 'good' message for farmers and the new methods meet the needs of small-scale farmers in Transkei itself and have a chance of being adopted there.

Technology

The data on crop production clearly indicates a tendency towards a farming system at a 'low level equilibrium', with little integration of crop and livestock production in the farming system.

The general lack of draught power, suitable implements and tools, as well as poor tillage is a constraint to improved crop production by individual farmers. Paradoxically, the problem of draught power is not a problem of draught animals per se, but rather one of their effective distribution and utilization. Although the Department of Agriculture has embarked on a program of mechanization in an attempt to solve the problem of draught power, the evidence suggests that consideration should be given to examining the possibilities of utilizing animal draught power co-operatively within appropriate integrated farming systems. Tractor power, preferably provided by local contractors, should supplement rather than replace animal draught power. Research is needed into the possibilities of using animal drawn implements more effectively for certain farming operations.

Because of the problems of tillage and draught power, there is an urgent need to investigate alternative tillage systems, such as 'no tillage', 'minimum tillage' and moisture conservation systems.

In overcoming the problems of poor plant population there is a need to propagate hand planting techniques as well as improve the efficiency of ox drawn planters.

As regards the current almost universal practice in Transkei of inter-cropping, there is sufficient evidence to suggest that researchers should evaluate inter-cropping systems with a view to improving the relevant technology in order to adapt it to present farming systems.

On-farm adaptive research is needed to investigate means of improving the organic matter status of soils, as well as determining optimum fertilizer applications under different managerial standards.

The failure of hybrid maize varieties due to managerial and other constraints, suggests there is considerable scope for systematic seed selection from locally grown cultivars.

There is a need to investigate labour saving devices for weed control, including improvement of hand tools and the use of herbicides using simple knapsack sprayers.

Since Qamata irrigation scheme involves a high capital and fixed costs, without going into detail, reorganization and reforms on this project warrant serious and urgent consideration. Besides agronomic practices, particular attention needs to be paid to effective and efficient irrigation and water control.

Besides farming systems technology, there is a need for technology for clean water supplies, alternative fuel for cooking, lighting, heating, etc., as well as food technology.

CONCLUSION

It can be concluded that there is an important need for Farming Systems Research in Transkei to identify traditional technologies at village level followed by testing and adapting appropriate technologies in order to overcome important constraints in present farming systems. At the same time, there is a need to provide institutional support and incentives such as an operational policy for agricultural development, land reform, improved extension and research systems, development of local organizations and leadership, as well as provision of farming inputs and marketing in order to increase the rate of agricultural development in Transkei.

A limitation of Farming Systems Research as currently practiced is that diagnosis and solutions to farmers problems tend to remain with the professional agriculturist or researcher. Farmers, especially those in the 'middle majority' category, should become more involved in identifying their own research needs and priorities through dialogue with scientists.

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Table 1. Summary of physical, institutional and human problems and constraints, system outputs and suggested solutions.

Factor / Variable	Problem / Constraint	Suggested Solution
1. PHYSICAL		
1.1 Soils	Depletion of soil fertility	Improved cropping practices. Integrated farming.
1.2 Vegetation	Veld deterioration and degradation. Fuel wood deprivation.	Grazing control and management. Establishment of wood loss.
1.3 Water resources	Under-developed primary and secondary water resources.	Planned conservation and development of primary and irrigation water resources.
1.4 Pests and diseases	Crop wastage. Low animal production and high mortality.	Adoption of modern biological and chemical control.
1.5 Land-use	Lack of detailed resource planning.	Detailed resource surveys. Adapted economic farming systems.
2. INSTUTIONAL / POLICY		
2.1 Policy	Loss of operational policy and specific objectives.	Balanced operational policy with realistic targets.
2.2 Planning	Lack of control agricultural planning organization.	Establish Central Agricultural Planning Authority directly responsible to Cabinet.
2.3 Rural Infrastructure	Poor water distribution, roads, communication, schools, etc.	Planned piped water schemes, roads, education centers according to area plan.
2.4 Inputs / services	Lack of readily available inputs, services	Establish rural service centers in districts.
2.5 Marketing / prices	Lack of organized marketing and price incentives.	Marketing and pricing policy for major products.
2.6 Credit	Lack of credit facilities.	Provide selective controlled credit.
2.7 Research	Lack of local agricultural research.	Develop suitable applied research structure.
2.8 Extension	Ineffective and inefficient extension.	Reorganize in time-bound Training and visit system. Balanced use of communication channels.
2.9 Land tenure	Lack of security and negotiability of land rights. Uncontrolled communal grazing.	Registration and negotiability of arable land rights. Cooperative grazing schemes.
2.10 Development coordination	Uncoordinated rural development approach.	Decentralized control and coordination policy at District. Regional and National level.
HUMAN RESOURCES Personal characteristics		
3.1 Age / sex ratio Migration	Insufficient males in productive age groups.	Institutional and agrarian reform to encourage bonafide farmers. Rural employment.
3.2 Education and training	Illiteracy. Low education levels. Urban oriented education.	Functional literacy and numeracy, adult education, home economics, health care, nutrition programs, youth programs.
Socio-economic		
3.3 Local organizations	Lack of suitable local organizations.	Institution of multi-purpose farmer organizations at District and Regional level.
3.4 Leadership	Lack of dynamic local leadership.	Leadership development and training.
3.5 Land tenure / farm size	Non-viable farm holdings.	Land reform program, (see 2.9). Alternative rural employment.
3.6 Labor	Labor shortages at peak periods.	Co-operation, contracting and land reform.
3.7 Living standards	Low living standards.	Policies for improved incomes, health, nutrition etc.
3.8 Nutrition	Inadequate nutrition (40%)	Increased food production – vegetables. Nutrition education.
3.9 Health	Nutrition related diseases.	Increased food production –clean water supplies. Health education
3.10 Water supplies	Inadequate clean water.	Participatory piped water schemes.
3.11 Fuel	Inadequate and expensive fuel.	Establish woodlots. Improved fuel technology.
3.12 Role of women	Large labor burden Neglect in development.	Technology to ease workload. Greater involvement of women in development programs.
3.13 Rural youth	Poor image for agriculture. Urban oriented education.	Rural youth education programs. Teacher training.
3.14 Farm income	Low farm incomes.	Increase farm and non-farm income. Rural employment opportunities.
Socio-psychological		
3.15 Managerial aptitude	Low management: levels.	Intensive farm management extension.
3.16 Decision making	Lack of decision making information.	Extension information to assist in individual decision making.
3.17 Aspirations / innovation	Low income and farming aspirations. Lack of motivation.	Provide educational and institutional incentives.
3.18 Attitudes	Negative attitudes to development.	Effective persuasive communication through extension.
3.19 Perceptions	Over optimistic perceptions of resource use.	Intensive extension and demonstrations.
3.20 Basic needs	Need for improved diet, health, water supplies. Education, consumer goods, etc.	Target based rural development program.
4 SYTEM OUTPUTS		
4.1 Crop production	Below subsistence production. Low yields and adoption of technology. Inappropriate technology. Lack of draught power.	Intensive extension. Appropriate technology Intensified and diversified production. Cooperative and contract ploughing and services.
4.2 Irrigation	Uncontrolled and inefficient irrigation.	Centralized management and control. Improved irrigation techniques. Close supervision.
4.3 Livestock production	Land degradation Low offtake and reproduction. High mortality.	Improved water supplies and fencing. Grazing control and management (see 7.9) Improve basic nutrition, management, and disease control.
4.4 Integrated Farming system	Little integration of crops and livestock.	Devise integrated Farming Systems through applied research.
4.5 Gross margin	Low grass margin and farm income.	Strategy, based on intensive extension with the necessary institutional support. (See 2 and 3 above).

Table 2. Carrying capacity of cultivated land by area.

Area	Present Cultivated Area ha	Yield Potential Tons/ha	Estimated Population	Estimated Subsistence Carrying Capacity	Surplus Carrying Capacity
Qamata	2 085	7,0	11 149	55 044	43 895
Emgcwe	2 062	2,5	3 180	19 444	16 264
Qumbu	5 449	3,5	9 463	71 926	62 283
Total	9 596	13,0	23 792	146 414	122 442

Crop	Value of Crop Production According to Area			Weighted Mean
	Qamata	Emgcwe	Qumbu	
	R	R	R	R
Maize	43,30	65,00	32,02	43,47
Beans	27,14	21,84	1,25	16,21
Sorghum	2,60	0,09	1,03	1,41
Wheat	29,06	0,17	0,00	12,12
Other	19,96	8,36	3,19	15,42
TOTAL	131,89	95,76	37,49	88,63
Garden	0,15	0,40	0,90	0,49
Orchard	0,23	0,33	0,74	0,44
TOTAL	132,27	96,49	39,13	89,56

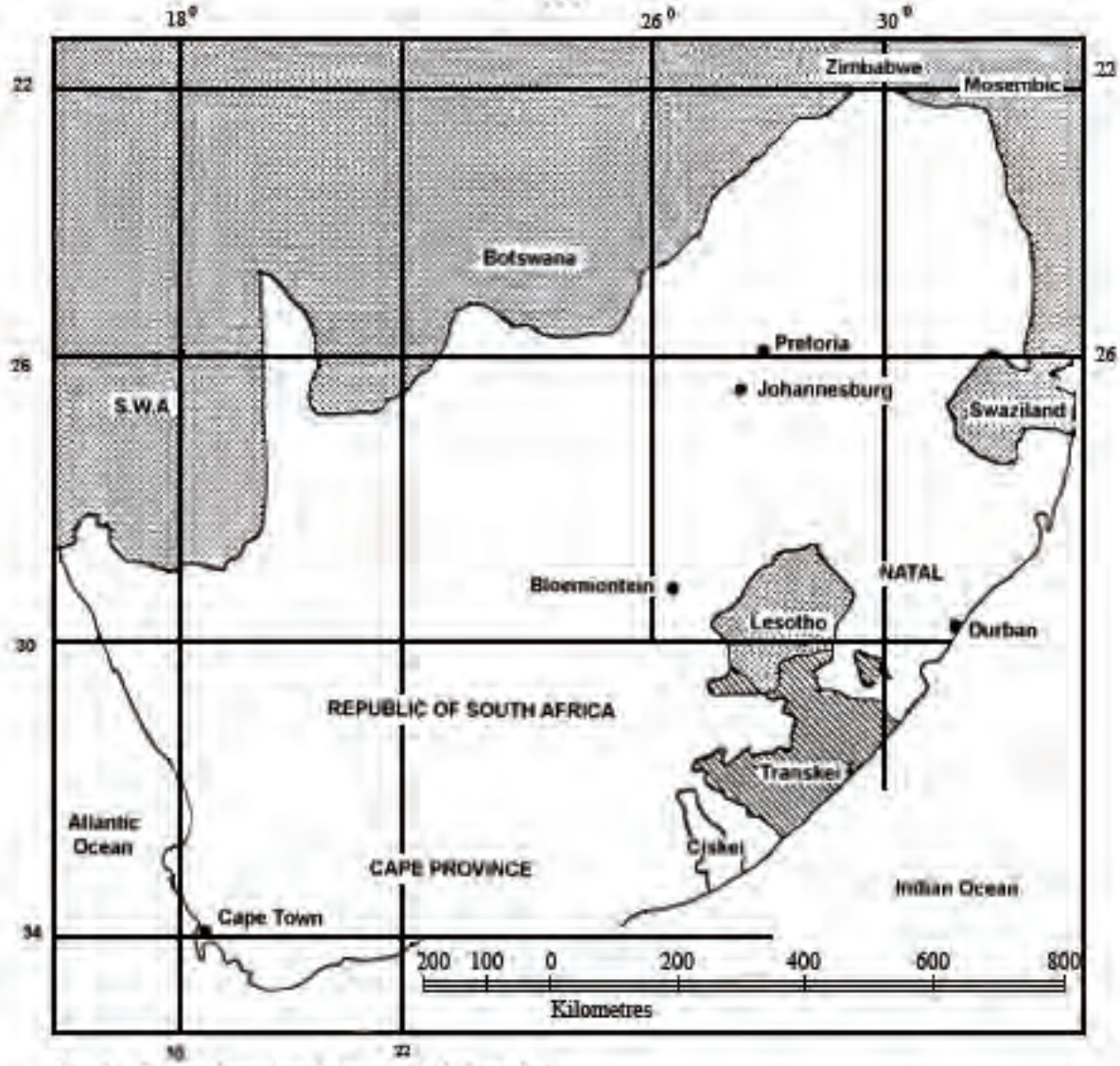


Fig 1. Map showing location of Transkei

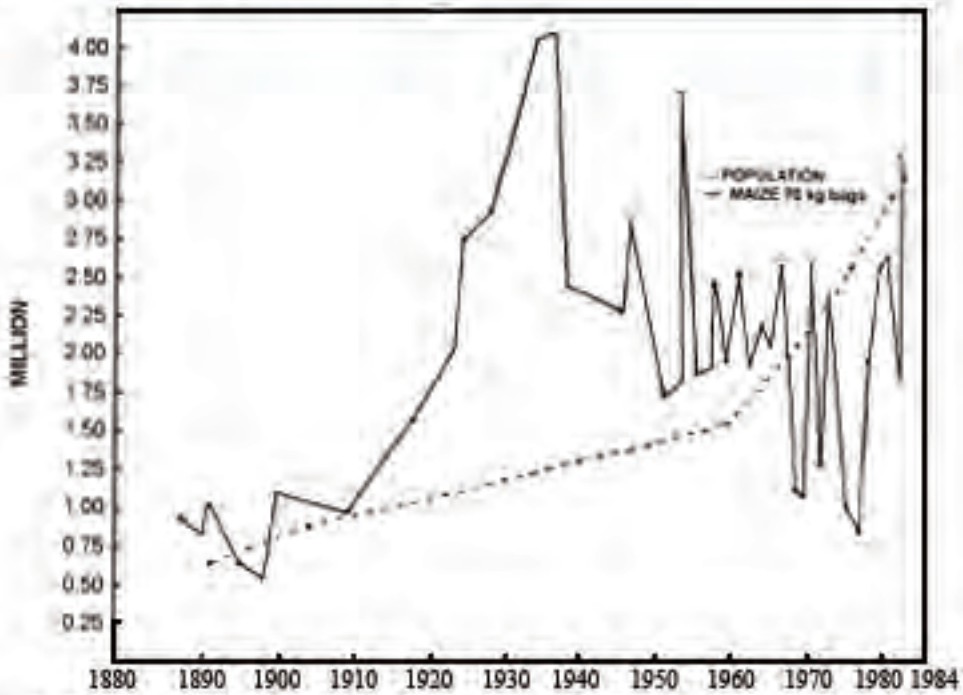


Fig. 2 Population (1891 - 1984) and adjusted total maize crip (1886 - 1984) in Transkei.

AGRO-ECOLOGICAL CLASSIFICATION TRANSKEI

AGRO-ECOLOGICAL UNITS AND THEIR MAIN CHARACTERISTICS (GENERALISED)			
MAP SYMBOL	ANNUAL RAINFALL mm	ALTITUDE RANGE (m)	RECOMMENDED PATTERNS OF AGRICULTURAL LAND USE
Ih	> 1000	Mountainous	Mainly afforestation
IL	> 1000	Mainly Rolling	Intensive perennial crops and livestock
IIh	800 - 1000	Mainly undulating to rolling. IIh Mt Mountainous	Intensive livestock and annual crops in summer
IIm	800 - 1000	Mainly rolling but with rugged plateau remnants	As above but with wider range of crops
IIL	800 - 1000	Rolling to rugged	Intensive livestock and sub-tropical crops
IIIh	600 - 800	Mainly rolling	Semi-intensive mixed farming. Cropping where soils are suitable
IIIm	600 - 800	Undulating to rolling	As above but with wider range of crops
IVh	< 600	Mainly rolling	Semi extensive livestock farming with some drought resistant crops
IVm	< 600	Mainly undulating to rolling	As above but with greater potential for irrigated cropping
IVL	<600	Mountainous except for valley floors	Mainly extensive livestock with some cropping in valley floors

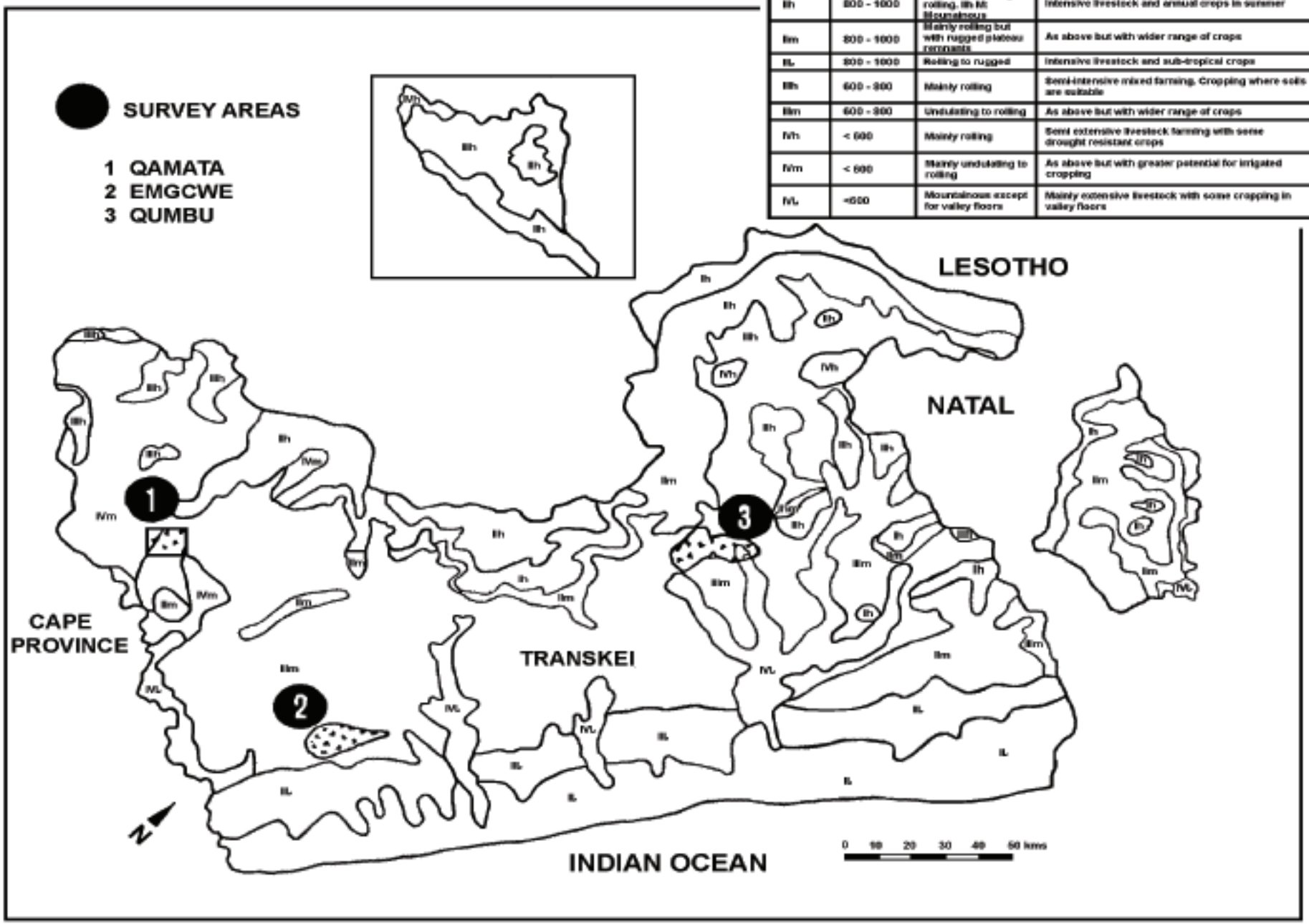


Fig. 3 Agro-ecological areas of Transkei showing survey areas (After Hawkins Associates, 1980).

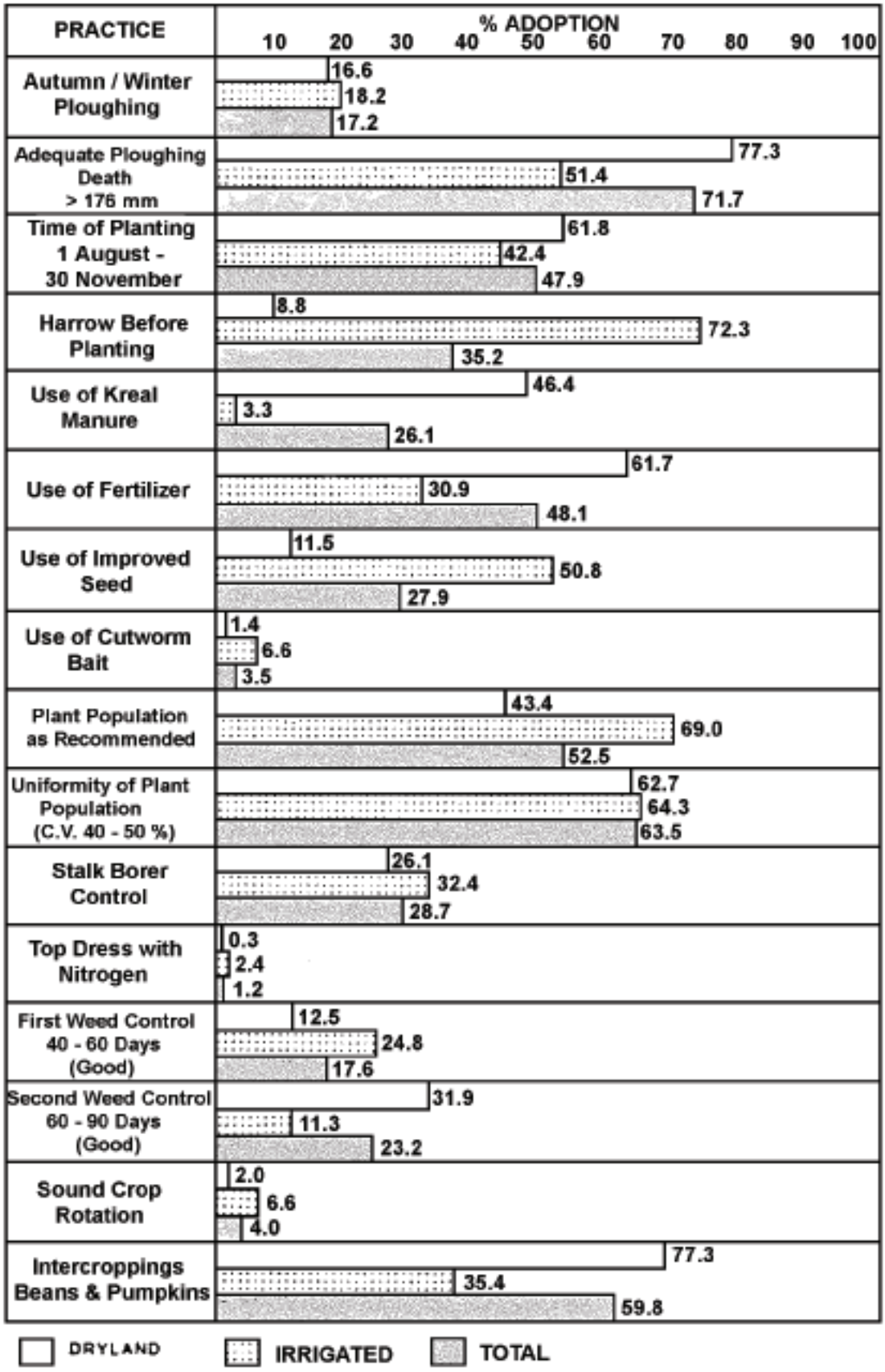


Fig 4. Per cent farmers adopting maize growing practices under rainfed and irrigated conditions.

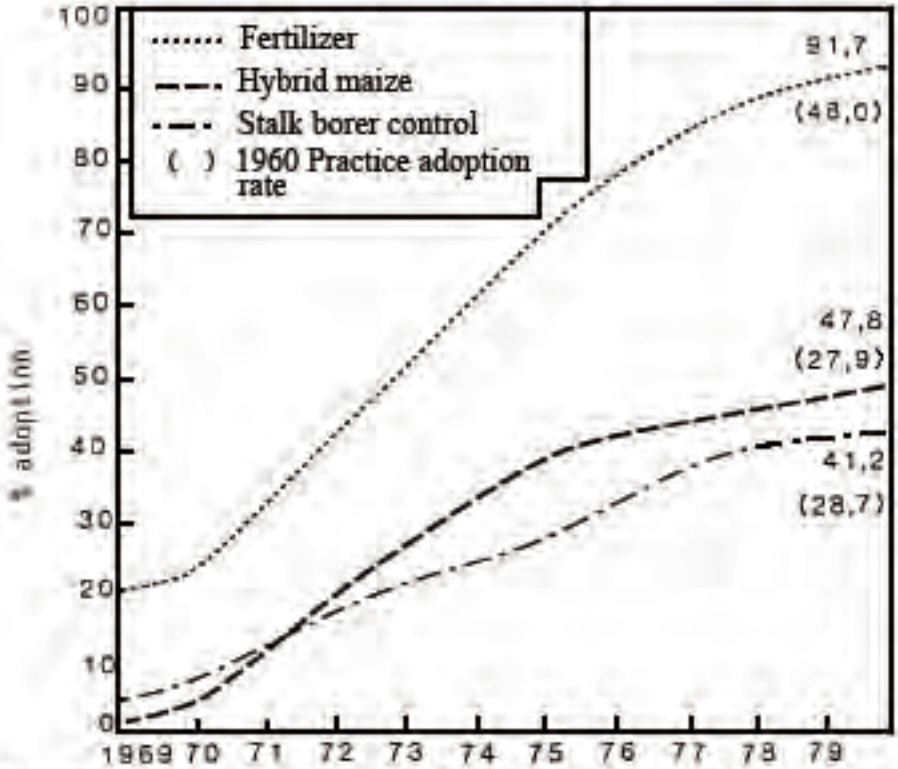


Fig. 5 Cumulative rate of adoption of three maize growing practices (N = 538).

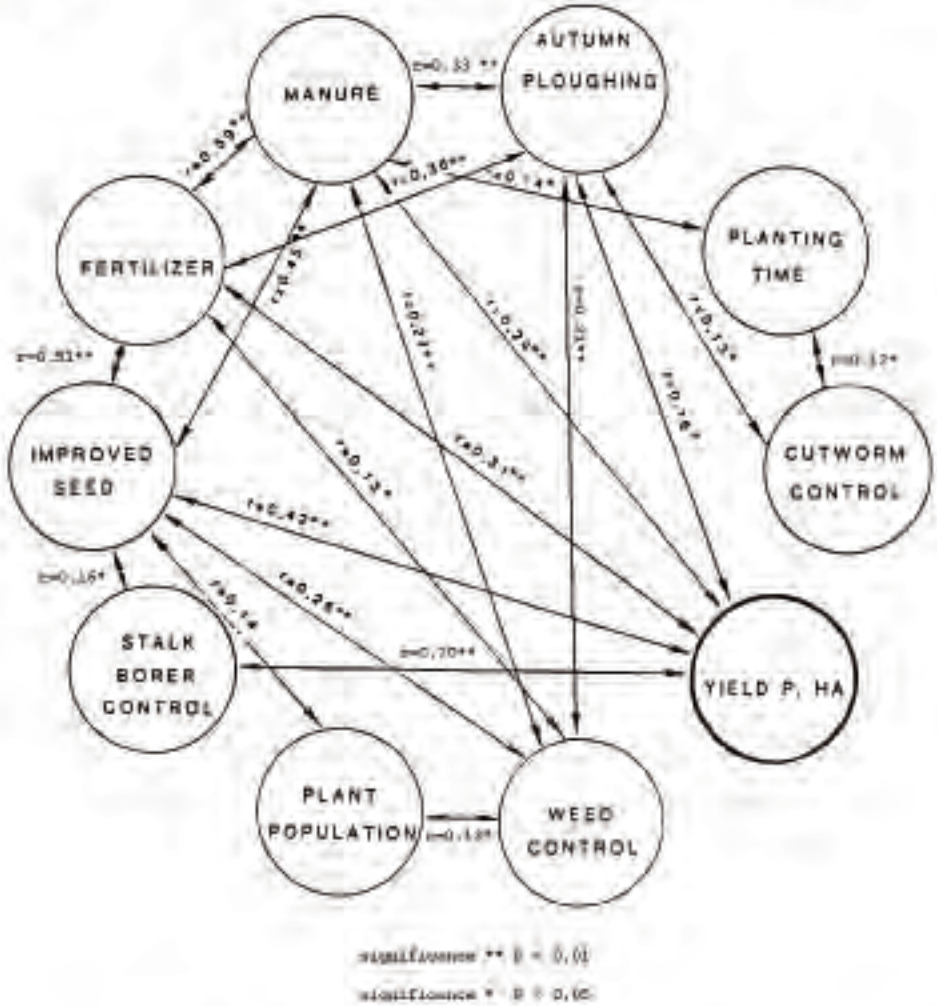


Fig. 6 The inter-relationship of maize production practices and yield per hectare, 1980 (N = 538).

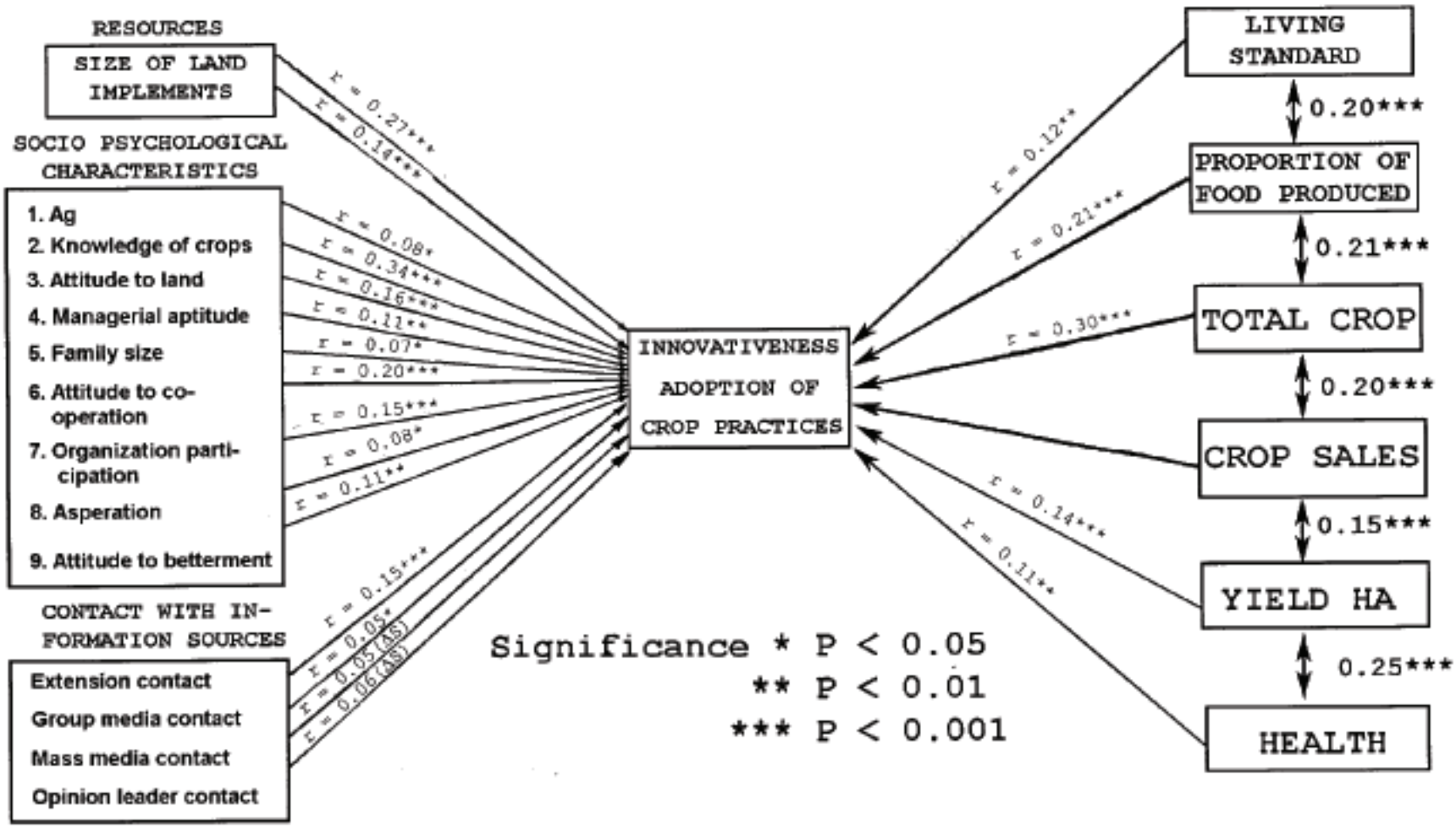
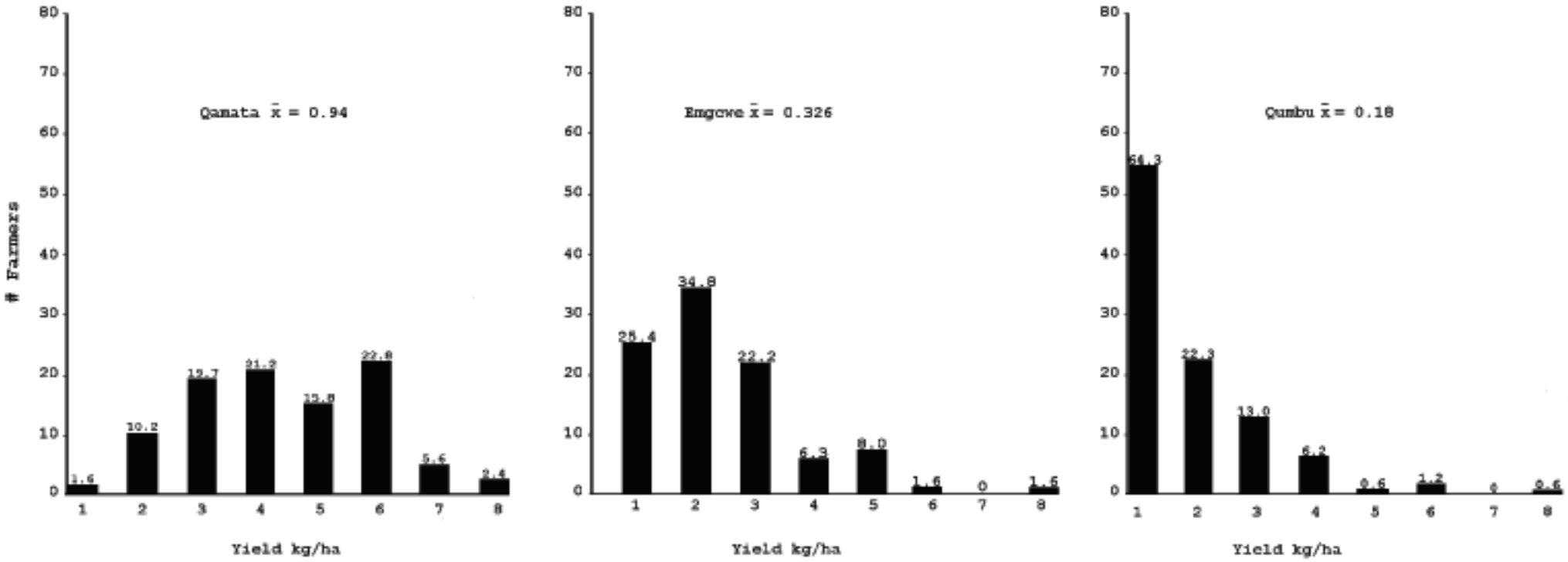


Fig. 7 Factors influencing adoption of maize growing practices, 1980 (N= 538).



Class Yield Range (tons/ha)	Class Yield Range (tons/ha)
1 - 0.10	5 - 0.70 - 0.99
2 - 0.10 - 0.29	6 - 1.00 - 1.49
3 - 0.30 - 0.49	7 - 1.50 - 1.99
4 - 0.50 - 0.69	8 - 2.00

Fig. 8 Distribution of maize yields in tons per ha according to area, 1980 (N = 538).

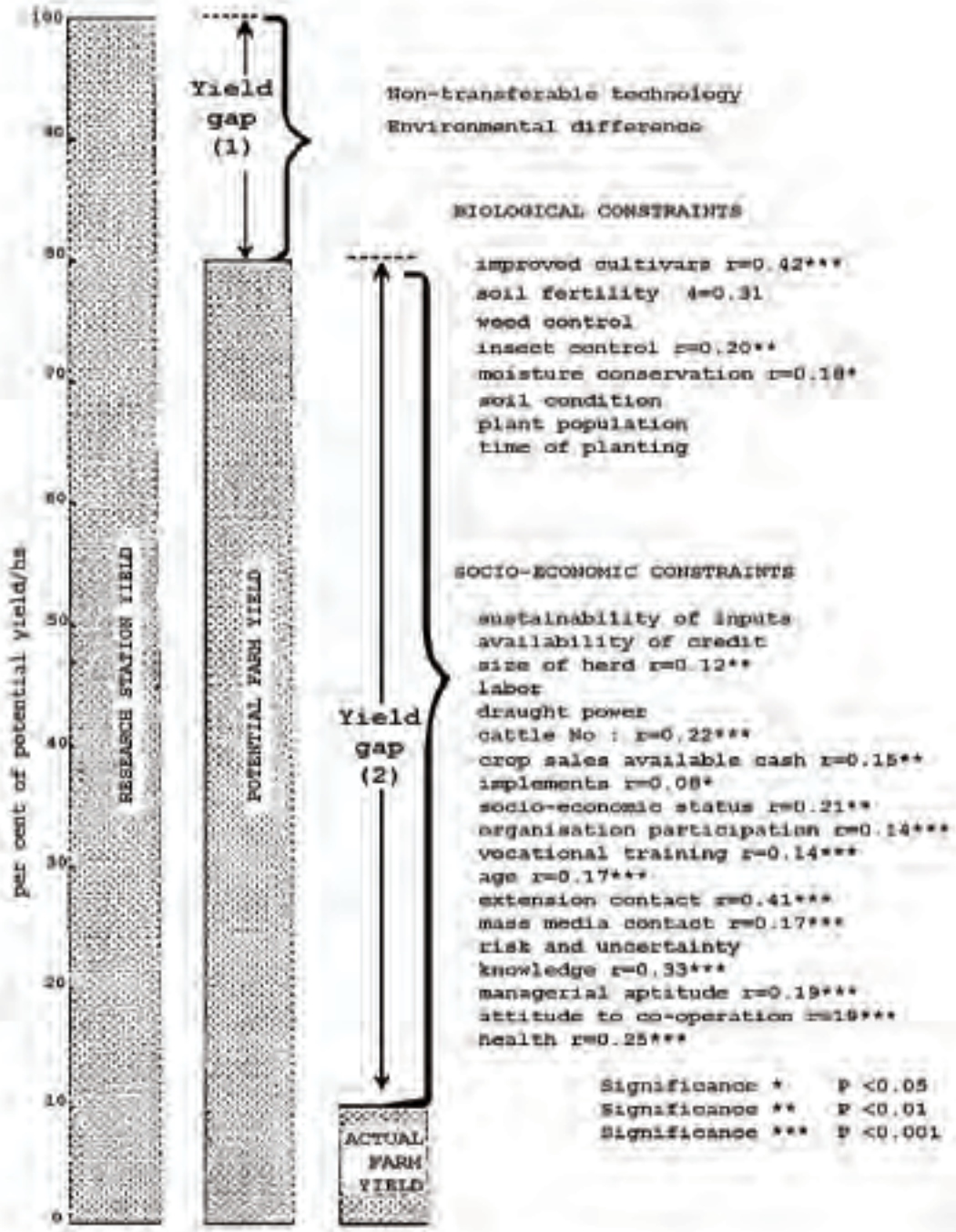


Fig. 9 Conceptual model explaining the gap between potential and actual farm yields of maize (After Gomez, 1977).

WEED MANAGEMENT STUDIES IN INTERCROPPING SYSTEMS IN TRINIDAD AND TOBAGO[1]

RICHARD A.I. BRATHWAITE[2]

ABSTRACT

Manual methods of week control are commonly employed in intercropping systems in Trinidad and Tobago but are often expensive and inefficient. Data from a 3-year survey describe the extent and timeliness of weed control by small farmers growing intercropped pigeon pea [*Cajanus cajan* (L.) Millsp.] in Central and south Trinidad. Field trials conducted in association with farmers have shown that careful selection of intercrops can significantly reduce weed infestation, with corn (*Zea mays* L.) and cowpea {*Vigna unguiculata* (L.) Walp.] being the most efficient weed suppression crops. The potential for the adoption of safe and effective herbicide treatments identified in specific intercrops is reported. The importance of integrated approached to week management which take into account ecological and biological interactions between the crops and the weeds is highlighted.

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1 Paper prepared for the Sixth Annual Farming System Research and Extension Symposium, October 5-8, 1986, Kansas state University, Manhattan, Kansas, U.S.A.

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INTRODUCTION

In Trinidad and Tobago, as in common in many tropical countries, the control of weeds is a major constraint limiting the production of field crops. Manual methods of weed control are commonly used by small farmers with about 25% of the actual expenditure on crop production being incurred on labour for weeding. Such methods are not only expensive but are tedious and often ineffective.

Intercropping, the growing of two or more crops simultaneously on the same piece of land without taking spatial arrangement into consideration is a common practice amongst small farmers. Aiyer (1949) suggested that farmers adopt the practice as an added insurance against crop failure because of their lack of accuracy in predicting environmental and soil conditions. That intercropping can provide significant yield advantages compared to sole cropping, and the more complete cover provided by intercropping reduces weed growth through competition, is indisputable.

In an earlier report (Brathwaite, 1985) some preliminary findings from studies on weed management in intercropping systems conducted in the Department of Crop Science were presented. The purpose of this present paper is to provide additional results from the ongoing research project and to stimulate discussion on areas for future work.

Full chemical names of the herbicides mentioned in the text may be found in Tropical Pest Management Pesticide Index, 1984 Edition (Tropical Development and Research Institute, London, U.K.), 'Weed Abstracts', 'Weed Science', and the Proceedings of the 38th Annual Meeting (1985) of the Southern Weed Science society. All quoted rates are in kilograms of active ingredient per hectare. All trials were replicated at least four times.

Weed control in pigeon pea intercrops survey

The extent and timeliness of weed control by a randomly-sampled group of small farmers who intercrop pigeon pea [cajanus cajan (L.) Millsp.] was studied in a survey conducted by the author during 1978, 1983, and 1985 in central and South Trinidad (Figure 1). Crops were cultivated under rainfed conditions and all farmers were interviewed during regular visits to their plots, at intervals of at least two weeks. The following are the main findings of the survey.

1. As previously reported (Henderson, 1965) corn (Zea mays L.) was the commonest intercrop being grown by all farmers in both areas studied. There was a definite preference to improved cultivars of both corn and pigeon pea over the years. In 1985 only 10% of the farmers planted cv. Local corn seeds they had collected and the corresponding figure for pigeon pea was 12% In the first year of the survey. 65% of the farmers grew collected seeds of local cultivars of the crops.

2. There was a constant trend in the spatial arrangements of the intercrop throughout all years of the study. Alternate rows of pigeon pea and corn and alternate planting of the crops within the row were equally common in occurrence. Other systems

Included one row of pigeon pea for every two or three rows of corn, One plant of pigeon pea for every two or three plants of corn within the row, and a random planting of the two crops. These systems were often observed in 1978 and 1983, particularly in central Trinidad, but were less in evidence in 1985.

3. In both 1978 and 1983 the majority of farmers, 82%, used wider than Normally recommended spacings. In 1985 recommended spacings were more often used and in Central Trinidad 2% of the farmers established the intercrops closer than recommended.

4. In all years farmers appreciated losses due to weeds and attempted to adopt some measure of weed control. Two weedings with long handle hoes were the common method employed but were often inadequate, irrespective of location. Generally weeding was timely with no significant difference over farm size (Table 1).

5. The most frequent losses stated by farmers were the direct competitive effects, interference with harvesting, and the increased need for attention to insect and disease control.

6. Particularly in south Trinidad the hosing operation resulted in spreading of vegetative propagules of Cyperus rotudus, Paspalum fasciculatum and Brachiaria platyphylla. On one farm in Central Trinidad Cynodon dactylon propagules were disseminated during hoeing.

7. Generally, the weed flora was similar in Central and South Trinidad with a predominance of grass weeds (Table 2). A list of the major weeds present in all years is given in Table 3.

8. Every year at least 83% of the farmers used directed and shielded post-emergence sprays of paraquat and/or paraquat plus diquat to supplement manual weeding.

9. Not more than 4% of the farmers used a pre-emergence herbicide treatment at planting the intercrops in any year of the survey. At least two farmers, who established their crops with a mechanical seeder, applied pre-emergence treatments of atrazine and prometryn separately in bands on the row of corn and pigeon pea, respectively, with excellent results. Herbicides used as pre-emergence treatments, with varying effectiveness and safety, included atrazine, chloramben and pendimethalin.

10. Moulding up was considered an important contributor to acceptable weed control by most farmers studied.

11. The use of small, engine-powered, walking tractors with cultivators is becoming increasingly popular.

12. The need for the adoption of a combination of different methods

Of weed control was appreciated by all farmers throughout the survey. However, they emphasized the need for the urgent identification of safe and effective herbicide treatments for at least early weeding because of the high-wage, labor-scarce situation in the areas studied.

Farmers who had observed weed control in pre-emergence herbicide trials conducted by the author in 1983 adopted the use of prometryn and/or alachlor in that year and again in 1985. Such adopters were satisfied with the performance of their treatments. Main criteria farmers employed to asses the treatments were the efficacy and selectivity of the herbicide, the cost of weed control and the returns from their investment.

Pigeon pea and other intercrops

Studies conducted at the University of the West Indies Texaco Food Crops Farm (Brathwaite, 1985) showed that intercropping pigeon pea with crops like beans (Phaselous vulgaris L.), corn, cowpea [Vigna unguiculata (L.) Walp.], mugbean [Vigna radiate (L.)], sorghum [Sorghum bicolor (L.) Moench>], and soybean [Glycine max (L.) Merr.] reduced weed infestation. The potential of this approach to the significant reduction of weed growth was further demonstrated in studies with cooperator farmers during 1985. corn and cowpea were consistently the most efficient weed suppression crops (Table 4 and 5).

Banana and cowpea

Intercropping banana with specific cultivars of cowpea has resulted in good weed control (Chacko and Reddy, 1981) and increased net returns (Rao, 1980, 1981). Two banana (cv. Robusta) intercropping trials involving two cultivars of bodie bean, cvc. Los Banos Bush Sitao No. 1 and kanhai, and sole crop banana were conducted at Las Lomas and Freeport on a Las Lomas sandy loan soil and Freeport and clay loam soil, respectively. Spacings were 2.1 x 2.1 m in banana and 4 rows of bodie bean 50 x 15 cm. The bodie was planted 12-16 days after the banana. Both cultivars produced a dense canopy which covered the entire soil and suppressed weed growth until they were uprooted after nin harvests at las Lomas and ten harvests at Freeport. The bodie plants served as mulch after their final harvest. The mulch further suppressed weed growth, added nutrients and humus to the soils (Table 6), and reduced soil moisture evaporation. Average yields of Los Banos Bush Sitao No. 1 and Kanhai were 13.3 and 7.3 t/ha at Las Lomas and 15.6 and 7.8 t/ha at Freeport, respectively. The two farmers realized increased total net returns from intercropping with bodie by 29.6 and 20.4% at Las Lomas and 32.4 and 18.9% at Freeport in Los Banos Bush Sitao No. 1 and Kanhai, respectively, over the sole crop banana.

Sweet potato and cowpea

Six selective post-emergence grass weed herbicide treatments were further evaluated in a bodie bean (cv. Los Banos Bush Sitao no. 1)/Sweet potato (cv. 049) intercrop on Pasea clay loam at St. Augustine in a wet season trial. The herbicide treatments were (1) alloxydim-sodium at 1.5, (2) fluazifop-butyl at 0.5, (3) fenoxaprop-ethyl at 0.36, (4) fenoxaprop-ethyl at 0.48, (5) quizalofop-ethyl at 0.05 and quizalofop at 0.1. All treatments were applied over-the-top when grass weeds were growing actively with

seedling annual grasses having 4 to 6 leaves and perennial grasses having 5 to 6 leaves per shoot. Agral 90 at a rate of 0.1% of spray volume was included in all treatments except fenoxaprop-ethyl. Treatments were applied in 200 liters of clean water per hectare. The site had a weed flora of mainly grass weeds; the predominant weeds were Echinochloa colonum, Eleusine indica and Brachiaria platyphylla.

Excellent control of the grass weeds at 14 days after treatment and complete kill of B. platyphylla and E. indica was achieved by 21 days after treatment with all herbicide treatments. Table 7 shows the effects of the herbicide treatments at 56 days after treatment.

None of the herbicide treatments produced visible crop injury. The date of blooming and maturity and plant stand of the crops were not affected by the treatments. Average yields of sweet potato were 12.3 t/ha. Fluazifop-butyl at 0.5, fenoxaprop-ethyl at 0.48 and quizalofop-ethyl at 0.1 gave bodie bean yields similar to the clean weeded check, 17 t/ha, and significantly better than the yields of the other herbicide treatments which were acceptable.

CONCLUSION

The results of the survey provide useful information on the weed management systems employed by the farmers. Such information is essential if we are to provide weed control approaches which are feasible as well as affordable to the farmers.

The weed suppressing ability of component crops in the intercropping system is clearly shown by the data presented. It is evident that enhanced weed control intercropping can be achieved by the combination of the most effective and economical methods. Such methods include better crop densities and spatial arrangements, the use of smother crops, and herbicides and mechanization. Such integrated approaches to weed management much take into account the various ecological and biological interactions between the crops and the weeds.

ACKNOWLEDGEMENTS

The author wishes to express his gratitude to the cooperating farmers; Messrs. Sarran Harryram and Oscar Brathwaite for technical assistance; Mrs. C. Commissiong for typing the manuscript; the various chemical companies for supplying herbicides and the Inter-American Institute of Cooperation on Agriculture, Trinidad and Tobago Office, for support of the work. The trials formed part of the Cereals and Other Grains and the Grain Legume Research Programs of the Faculty of Agriculture.

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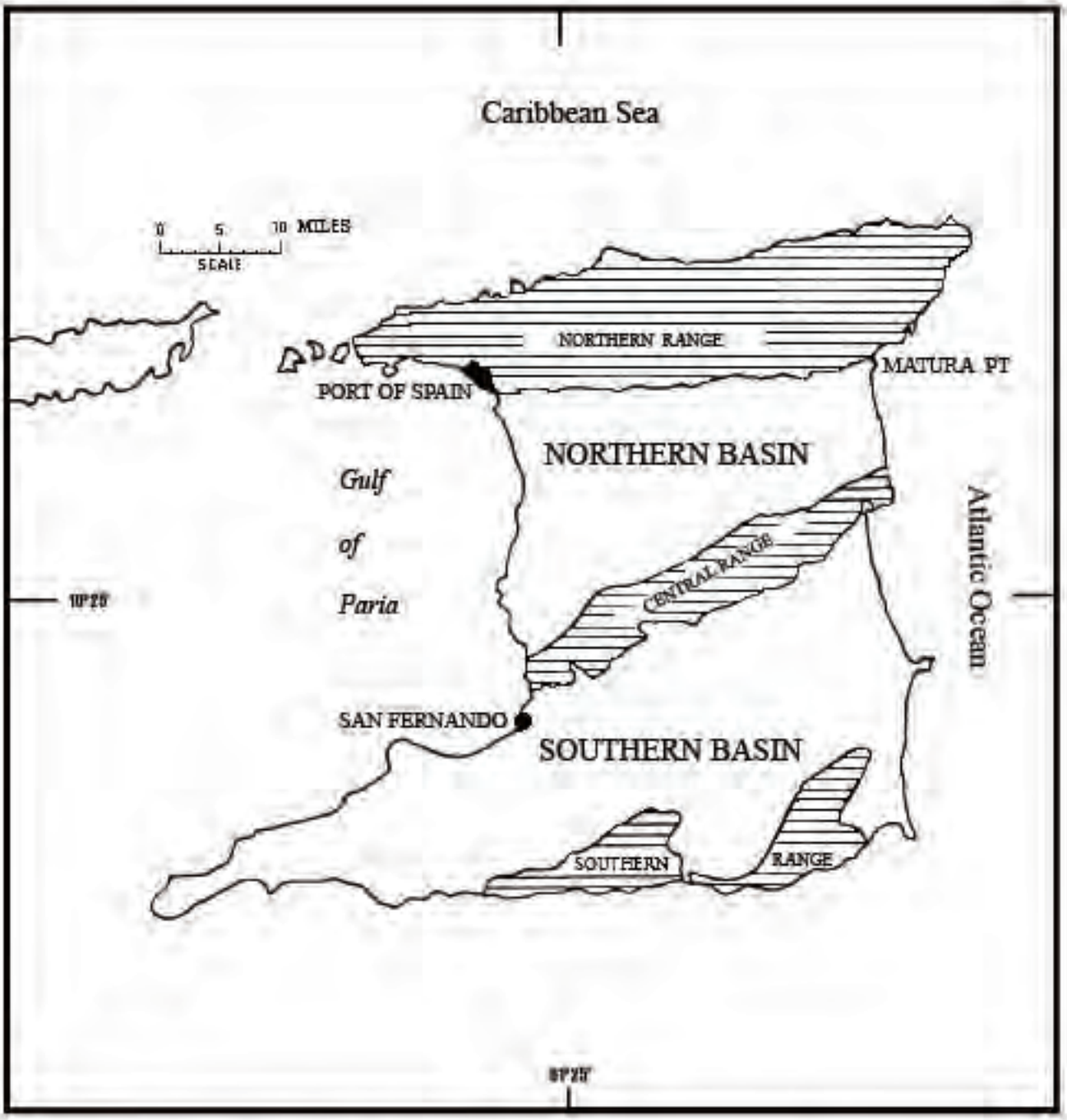

Fig. 1 MAJOR PHYSIOGRAPHIC REGIONS OF TRINIDAD

Table 1. Weed control by hand-weeding in pigeon pea/corn intercrop in Central and south Trinidad during 1978, 1983, and 1985.

Farm size (ha)	Number of weedings		Number of Days to			
			First weeding		Second weeding	
	Central	South	Central	South	Central	South
<0.49	2.3*	2.2a	20.0a	20.7a	39.9a	44.2a
0.5-0.99	2.2a	2.4a	19.6a	18.2a	38.7a	43.6a
1.0-1.99	2.3a	2.3a	20.0a	17.4	39.5a	44.7a
2.0-4.99	2.0a	2.3a	21.4a	20.1a	39.9a	42.7a
75.0	2.2a	2.4a	21.1	18.2a	39.3a	42.9a

*Means within columns followed by the same letter are not significantly different at the 5% level using
Duncan’s multiple range test.

Table 2. Weed flora (% distribution) in pigeon pea/corn intercrop in Central and south Trinidad during 1978 1983 and 1985

Weed flora	Central			South		
	1988	1983	1985	1978	1983	1985
Grasses	63	58	60	66	62	65
Broadleaved weeds	27	37	34	30	30	32
Sedges	10	5	6	4	8	3

Table 3. Major weeds of the weed flora in pigeon pea/corn intercrop in Central and south Trinidad during 1978, 1983 and 1985.

GRASSES:	*Echinochloa colonum*
	Eleusine indica
	Digitaria spp.
	Paspalum fasciculatum
	Brachiaria spp.
	Rottboellia exaltata
	Cynodon dactylon
BROAD-LEAVED SPECIES:	
	Parthenium hysterophorus
	Amaranthus ssp.
	Portulaca oleracea
	Phyllanthus amarus
	Cleome ciliate
SEDGE:	*Cyperus rotundus*

Table 4. Relative weed-suppressing ability of selected crops in pure stands in Central and south Trinidad

Crop	Weed-suppressing ability (%) at 68 days after planting		
	Texaco Food Crops Farm	Central*	South**
Beans	73	59-76	64-76
Corn	96	90-96	92-94
Cowpea	92	89-93	86-91
Mungbean	81	63-85	73-78
Sorghum	76	72-78	70-76
Soyabean	80	75-83	78-80
Pigeon pea	46	46-52	43-50

*Range at 8 farmers’ sites
**Range at 6 farmers’ sites

Table 5. Effects of intercropping pigeon pea with selected crops on growth of weeds 6 weeks after planting in Central and South Trinidad.

Crop combination	Weed dry weights (g/m^2)		
	Texaco Food Crops Farm	Central	South
Pigeon pea/beans	145	168	148
Pigeon pea/corn	96	90	100
Pigeon pea/cowpea	103	96	102
Pigeon pea/mugbean	115	120	130
Pigeon pea/sorghum	128	143	183
Pigeon pea/sole crop	320	402	330

Table 6. Biomass production and compositional contents in cowpea cultivars intercropped with banana.

	Cowpea cultivars			
	Las Lomas		Freeport	
Component	Los Banos Bush Sitao No. 1	Kanhai	Los Banos Bush Sitao No. 1	Kanhai
Above ground fresh weight (t/ha)	66.3	94.5	78.3	98.3
Above ground dry weight (t/ha)	6.5	8.2	7.4	7.2
Nitrogen (kg/ha)	150.1	145.0	143.3	136.3
Phosphorus	10.4	10.2	9.8	7.5
Potassium	69.7	52.4	52.6	45.3

Table 7. Grass control at 56 days after treatment in bodie bean/sweet potato intercrop.

Treatment and rate (kg a.i./ha)	Grass A	Control B	(%)* C
Alloxydim-sodium 1.5	90	95	86
Fluazifop-butyl 0.5	98	100	100
Fenoxaprop-ethyl 0.36	96	95	98
Fenoxaprop-ethyl 0.48	98	98	100
Quizaloprop-ethyl 0.05	99	100	100
Quizaloprop-ethyl 0.1	100	100	100

*A = B. colonum B = E. indica

C = B. platphylla

SEQUENTIAL PROGRAM PLANNING AND ADAPTIVE RESEARCH: AN APPLICATION IN THE NUBA MOUNTAINS AREA OF SUDAN

BY: Thomas E. Gillard-Byers and M. Trent Bunderson*

INTRODUCTION:

The Nuba of Southern Kordofan Province, Sudan are sedentary producers living in the Nuba Mountains. The Western Sudan Agricultural Research Project (WSARP) was mandated to provide agricultural technology transfer for the rainfed sector of Western Sudan. The Kadugli Research Station, located in Kadugli, Sudan undertook research designed to promote economic development among the Nuba as one recommendation domain representing the non Arab sedentary farming system. The introduction of ox-cart transportation provides a vehicle for such a technology transfer and may provide the means for development of a revolving credit program at the village level. This was made feasible through adaptive program design and adaptive research and extension efforts on behalf of producers and technical assistance.

Location:

The villages in which experiments and extension were undertaken are located in Southern Kordofan Province, Sudan. The province is located between 9 degrees and 13 degrees North Latitude and 27 degrees and 33 degrees East Longitude. Figure 1 presents a map showing political boundaries and locations of major towns, some of which are referred to in the report.

The research program was undertaken using the Kadugli Research Station of the WSARP as headquarters for the study. Kadugli, Sudan is a provincial capital of Southern Kordofan and is located at 11 degrees 0 minutes North latitude between 29 and 30 degrees East longitude. The program area extended from approximately 45 kilometers SW of Kadugli to 50 kilometers North of Kadugli. During the three years of adaptive research and implementation five villages were targeted for cooperation. These villages were Kululu, Sema, Bilenya, Katcha and Kweik. Each of these villages is located within the area described above.

Environment:

Southern Kordofan Province of Sudan encompasses several climatically different environments associated with differences in latitude, longitude and elevation. The peoples described in this report live in the Nuba Mountains area.

The Southern Kordofan province is located within the Sudan-Sahelian savanna zone. Altitude varies from over 1000 meters in the Nuba Mountains, located in the central and Southern area of the province, to less than 500 meters above sea level in the plains areas. The Southern part of the province is characterized by undulating plains broken by the Nuba Mountains which outcrop across the area.

Temperature:

Long term temperatures for the Southern part of the province vary from a minimum of about 18 degrees centigrade in January to over 40 degrees centigrade in March and April. Mean temperatures range from a low of 27 degrees to a high of around 31 degrees centigrade.

*Lilongwe (C), Dept. of State, Washington, D.C. 20520

Precipitation:

Rainfall, both effective and total, is highly variable across years and across space. The long term mean rainfall for Kadugli is 732.0 mm. The rainfall during 1984 was 478 mm., 268 mm. and 363 mm. at the WSARP compound, Bilenya and Kululu respectively (Woldetatios, 1985).

Soil:

Soil structures vary in the Nuba Mountain area. Dark brown, deep cracking clays are the most extensive soils. These soils, also referred to as cotton soils, are similar in structure, texture and physical characteristics to vertisols which were classified by Buol (1980). Hunting Technical Service (1976) refer to theses soils as predominantly alluvial in origin and similar to alkaline vertisols.

A second major soil type in the area is the Gardud soil. This soil is a medium to heavy textured alluvial soil. Textures range from loam and clay loam in the top 50 cm. to sandy clay loam, sandy clay and clay in the subsoil (HTS, 1976).

The third major soil type is the Qoz sandy soil. These soils are yellowish red sands, loamy sands, and sandy loams which are acid in reaction and low in all macro and micro nutrients (HTS, 1976). These soils are more prevalent in the Northern parts of Southern Kordofan Province. Soil types according to landform are presented in Figure 2.

Socioeconomic:

The Nuba peoples occupy the mountains and cultivate the surrounding plains in the Nuba Mountains area of Southern Kordofan, Sudan. They are generally considered autochthonous to the area and may have controlled larger areas of South Kordofan prior to the arrival of the Arabs (South Kordofan Planning Unit, 1978). The Nuba are represented by approximately fifty negroid tribes. The distinctness of the tribe is to a great extent a matter of name and location. Differences exist with respect to certain agricultural production techniques and dialects but cultural differences are minimal.

With the entrance of the Arabs into the Southern Kordofan area the Nuba were forced to take refuge in the jebbels (mountains) for protection. Only recently has a down slope migration occurred which has provided the Nuba access to more land for cultivation. At the present time the Nuba in the villages represented in this report have moved to the foot slopes of the jebbel and are cultivating the plains as well as the jebbel foot slopes.

Location of Settlements and Composition of the Household:

Abu Sabah (1985) has provided a comparison of settlement by type of site from two different surveys. This information is presented in Table 1. In earlier years more Nuba would have lived on the ridges of the jebbel.

Abu Sabah (1985) provides household composition data in Table 2. The difference which exists with respect to the two surveys identified in the Table 2 is associated with location and the inclusion of non Nuba households in the formal survey.

Kinship Among the Nuba:

Araujo (1981) outlined kinship arrangements of the Shatt. The Shatt are a Nuba group living in Shatt Damam which is located between Katcha and Kululu, Sudan. For the purposes of this paper Araujo's comments can be generalized to other Nuba tribes which participated in the ox cart experiment. However, it should be kept in mind that major differences do exist with respect to kinship and should be identified prior to implementation of certain farmer/managed trials.

The Shatt are matrilineal in the manner which they reckon decent. Extended kin groups referred to as clans function as controls to regulate incest, civil disputes and other social agenda (Araujo, 1981). The clan is broken into subgroups which participate actively together in social functions such as feasting following harvest or in response to births, deaths and marriage ceremonies.

A preferred marriage arrangement is a matrilineal cross-cousin marriage in which a young man will marry his mother's daughter (Araujo, 1981). Other patterns of marriage exist with the most prevalent being the marriage outside of clan. This may include the marriage of men and women from different clans or from different tribes.

The nuclear family consists of a man, his wife or wives and their children. If a man has married more than one wife he will be expected to care for each family in the same manner. This care would extend to the provision of house, produce and storage facilities.

The Sibir and the Kujur:

Agricultural activities are often times preceded by what is called a Sibir. The Sibir is a celebration which is organized by the Kujur (religious leader). Sibirs mark the beginning of planting and harvest, the maturing of crops, the coming of rain and wrestling which is a major social function participated in by adolescent and young adult males (Gillard-Byers and Azrag, 1985). The status of the Kujur varies among different Nuba tribes. The power of the Kujur emanates from his position as organizer of specific community affairs and his position as healer in the village. In certain situations, such as the date of harvest of fields, his decision may not be questioned in certain villages. One hundred percent of the respondents to a questionnaire in Katcha said that the Kujur was the only person who could authorize harvest of the far fields (Gillard-Byers and Azrag, 1985a). Without the Kujur's authorization harvest would be postponed.

Nature of Production System:

Both crop and livestock production are undertaken by the Nuba household. Cropping activities occur in three general areas. The Jubraka (house garden) is the area around the farmstead. The near farms are located in areas where sandy soils exist usually close to the household. The far farms are located in the plains areas some distance away from the jebbels.

The size of the Jubraka varies between one habil and twenty three habils (Abu Sabah, 1985). One habil is equal to approximately .5 feddans or .5 acres. The average size of the Jubraka was 1.7 habils. Crop production on the Jubraka is oriented around short maturing varieties of sorghum, sesame, lubia and maize. Production of groundnuts, kerkadeh and vegetable crops such as pumpkin, tomato, cucumber and watermelon is also undertaken. These crops are produced for household consumption and sale when surplus exists. The short maturing varieties of grains and legumes provide food during the "hunger period" which occurs during the period August through November (Gillard-Byers and Azrag, 1985).

Jubraka enterprise management of production and marketing is undertaken primarily by the wife in the household. Management takes the form of labor allocations and control over the disposal of harvested crops. With respect to these management activities Abu Sabah (1985) found that 26% of the decisions were made by men, 52% were made by women, and 22% were made under joint management. This information is presented in Table 3.

The near farm in six different villages ranged from 1.3 feddans to 1.8 feddans while the far farms size ranged from 4.7 to 8.4 feddans (Araujo, 1981). The near farm differs from the Jubraka in the following ways: 1) a smaller variety of vegetables are grown, 2) it can be owned by either men or women, 3) it is slightly larger and, 4) it is located on sandier soils normally located closer to the Jubraka than are the far farm plots.

The far farms are the major production unit for the household and provide the main source of food during the period December through July. The major crops produced on the far farms are long maturing varieties of sorghum, sesame, and lubia with kerkadeh and cucumbers intercropped or monocropped.

The far farms are located in the clay plains a considerable distance from the house. Araujo (1981) has estimated these distances on average to be 7 kilometers.

Labor allocations for the far farm enterprises differ from those made in the Jubraka. Males provide the majority of labor allocated to far field production. Both hired labor and nafir labor are predominantly allocated to far farm production. A labor pooling occurs during periods of the cropping season when labor is in short supply. These labor groups are known as nafirs. During the weeding of the far farms the nafirs will be composed of male labor parties whereas during the harvest the nafirs for transport will be made up of female parties. It is the female transport nafirs which provided the stimulus for the evolution in design, implementation and evaluation of the research program presented below.

Livestock enterprises include cattle, sheep, goats, pigs, chickens and ducks for sale and household consumption. Cattle, sheep and goats are grazed on the plains and the Jubraka depending upon the time of year. Large ruminants will be housed in Zaribus (stables made out of thorn bush) while small ruminants will be housed in buildings which are part of the household complex.

Credit is virtually non existent among the Nuba. Normally, only during severe drought is credit made available and this is usually for food. Credit takes the form of food for cash or crops at a later date.

OBJECTIVES:

Over the three years that the ox cart program evolved different objectives were introduced to fine tune, target, expand, and redirect the experiment. The adjustments were necessary to insure a technological package which was both labor substituting and adoptable. Yearly program objectives are listed below. These provide a feel for the flexibility which existed within the overall objective of reducing labor allocations associated with production activities.

During year one the Range/Livestock section's general objective was the testing of ox cart technology for the movement of grass hay from fields to storage areas close to the beit (house). This was part of a broader diagnostic activity using oxen for draft power. Specific objectives included:

1. The transport of forage in a researcher-managed experiment involving the harvesting, transport, and storage of native hays for livestock feed (Bunderson, 1985).
2. Use of the ox cart in on-farm trials in two locations.
3. Determination of preferences as to the use of the ox cart through producer choice.

During year two the Socioeconomic section in collaboration with the Range/Livestock section altered the investigation to focus upon the following specific objectives (Gillard-Byers, Bunderson and Azrag, 1985):

1. Describe and document activities undertaken by producers in Kululu, Sudan with use of oxen and ox cart technology.
2. Estimate labor savings associated with the movement of Dura (sorghum) heads from the field to the threshing area.
3. Estimate labor savings from the movement of other commodities such as sesame and grasses.
4. Determine what other activities would be undertaken if the use of animal draft were available.
5. Elicit the rental value of the ox cart and net benefits which would accrue to the owner.
6. Determine the fixed and variable costs associated with purchase of equipment and oxen.
7. Estimate the secondary benefits associated with social welfare gains expected from labor savings across households.
8. Estimate benefit/cost ratios for determination of adoption potential.

Following evaluation of results from the researcher/fanner-managed trials of 1984 the program was expanded to include the development of a village level credit program. Validation of previous results and implementation of the technology were also undertaken. Farmer managed trials were based on year 1 and 2 results. Prior to the beginning of the experiment in 1985 the technical assistance contract expired. Year three objectives included:

1. Training six operators in the use and maintenance of oxen and equipment.
2. Identification of alternative employment opportunities which exist for women who would no longer need to participate in nafir labor activities.
3. Validation of elicited coefficients from year 2 through farmer-managed trials.
4. Development of a revolving credit program to provide capital For the purchase of equipment, oxen and future agricultural Input loans.
5. Develop linkages between producers in target villages and the Nuba Mountain Rural Development Project for future animal traction program opportunities.

YEAR THREE METHODOLOGY:

Bilenya and Sema, Sudan are located approximately 20 and 8 kilometer respectively, South of the Kadugli Research Station. These villages were chosen by the Range/Livestock Section for researcher-managed trials using ox cart technology. Forty-five producers participated in the experiment. Producers were chosen on the basis of their interest in the experiment. Ox-carts were used by the technical assistance team to move commodities of producer choice to storage areas. Oxen and ox cart equipment were provided by the Nuba Mountain Rural Development Project for the experiment in each of the program years.

YEAR TWO METHODOLOGY:

Year two research was conducted in Kululu, Sudan in an attempt to increase information flow in the area about the potential uses and benefits from the ox cart technology. It was also designed to increase community interest in other activities undertaken by the WSARP in that location.

Thirteen farm household heads were identified from a list provided by the area Sheik (village leader). Twelve of these individuals participated in the transport of Dura (sorghum) heads from the cracking clays to the threshing area. The thirteenth participant moved sorghum stalks from the far farm to the beit. These households were observed during the transport operation and subsequently interviewed about their preferences for use and constraints associated with use of oxen for transportation. Flexibility was built into the experimental design to allow for transport of other commodities after Dura heads had been transported.

Participants were accompanied during use of the ox carts to provide advise and record activities. Technical assistance was supplied for the operation and maintenance of oxen and ox cart during operation and while oxen were at rest.

The thirteen producers were interviewed after participation using a questionnaire developed by WSARP staff. The questionnaire focused upon labor savings, cooperative activities undertaken by family members at harvest time, the rental value of the ox cart to the household and time associated with transport of grain from field to threshing area. Technical assistance staff maintained records on the actual use of the cart, time associated with movement to and from the field, grazing and supplemental feeding requirements.

YEAR THREE METHODOLOGY:

The year three program was undertaken in Katcha and Kweik, Sudan. Katcha is located seventeen kilometers Southeast of Kadugli. Kweik is located thirty kilometers North of Kadugli along the Kadugli-El Obeid, Sudan road. Choice of location for the year three experiment was made with the objective of expanding the area in which the concept of using ox-carts was known and in the case of Kweik, introducing the concept in a village composed of Arab and Nuba villagers.

During year three the program was modified to include a means of generating revenues necessary for the purchase of equipment and oxen. This modification was made for two reasons. First, credit for capital purchases was limited in Kweik and Katcha. In the Nuba villages credit is made available only under the most dire circumstances and then only for minor purchases in the local market to be repaid with produce at a later date. A similar credit source does exist in Kweik but not at a level necessary to purchase the equipment. Secondly, the Agricultural Bank of Sudan was not operating in the area at the time and therefore precluded the use of funds from that source. Therefore, it was necessary to generate revenues to cover costs. This was done through rental of equipment and oxen based upon year two results.

The credit system was to be administered by a council of Sheiks who would oversee the use of the oxen and collect the rental fees in either produce or cash at the time of the operation. Oxen and equipment were provided by the Nuba Mountain Rural Development Project as in the prior two years. The following year new equipment would be purchased by the council of Sheiks for the village and in subsequent years revenues would provide a source of operating capital for producers in the village.

Documentation of rental revenue uses was undertaken through record keeping by technical assistance in conjunction with the Sheiks. Fixed and variable cost data was collected by the research team during on-site visits. Verification of disbursements were provided by the Sheiks for labor charges, maintenance and supplemental feeding costs. Thirty-two households in Katcha and one-hundred twenty thousand households in Kweik participated in the use of the ox cart technology.

Unfortunately, the technical assistance contract expired prior to the implementation of year three farmer managed trials. Information on results presented in the paper were provided the author by his junior technician after the author had left Sudan in November of 1985. Only partial results are available for year three and these pertain only to Katcha.

Experimental results from Kweik are not available due to the desire of producers in the village to continue the use of the equipment during other periods of the year. Results provided in the paper focus on year two and year three experimental activities.

Participant Characteristics:

During year two information was collected on characteristics of participants in Kululu, Sudan. This information is provided below and is assumed to be homogenous for other villages where the program was introduced. Therefore, it was not collected again in year three. This information in combination with that from secondary sources provided the necessary background to implement the farmer managed trials of 1984-85.

The median age of the participants was 37.5 years. Of these individuals, average years of education was .8 years. One of the participants had six years of education.

The lineage factor is interesting in terms of dissemination of information about technology. The mean number of relatives of the participants living in Kululu was twenty-six. This ranged from a minimum of six relatives to a maximum of seventy. When asked whether the participants would be willing to pass information about their use of animal draft to others, 90.9% responded in the affirmative. One might expect dissemination of information about the technology to be transmitted with a minimum of effort.

Labor Characteristics:

It was hypothesized that the introduction of animal draft for transportation would provide considerable labor savings due to reduced labor requirements for transport using human power. The producers of the villages perform many activities together in work parties (nafirs). The nafir reduces the time necessary to transport sorghum heads to the threshing area and is used in many other activities requiring transport or large inputs of labor. At some point during the year, 81.1% of the Kululu producers interviewed used nafir labor.

One of the distinguishing characteristic of the producers in Kululu and surrounding villages is their lack of use of oxen or other animals for transportation activities. With the exception of donkeys and occasionally a camel all transportation is done by human labor. When asked why they do not use livestock for transporting crops from the fields, 83.3% of the producers answered that they were not familiar with the concept. The other 16.7% said that they had no livestock. A remarkable 91.6% said that they had no concept of ox cart technology.

Nafirs have substituted for animal transportation. An average of fifty trips, on foot, were made by relatives involved in transport nafirs for the transport of Dura heads from the far fields to the threshing area. Each woman carried an average of 14.4 kg of Dura heads every trip. These were one-way trips, while the mean number of trips necessary for the transport of Dura was one hundred and one for the participants, calculated

on the number of trips made by each member of the nafir. The nafir may consist of over thirty women depending on the size of the harvest, distance to the threshing area, and the ability of the owner to provide cash and/or goods in kind for payment. During 1984 the distance walked required half an hour, while the maximum reported was 2.5 hours. The median time for travel was reported to be 1.4 hours. Imputing distances from time in this case is difficult due to topography. Estimates of the distances traveled to the far fields ranged from 1.6 km to 8.3 km. 1985 results from Katcha were quite similar to those for Kululu. The mean total distance walked to and from the far fields was 12 kilometers. This is in line with estimates on distance to far fields compiled by Araujo (1981). The mean time which was required to move to the far fields was 70 minutes. The time returning from the fields was 68 minutes. Both of these measurements are quite similar to those estimated during 1984 trials.

The division of labor between cutting of Dura heads and transporting the produce is quite distinct. One hundred percent of the respondents indicated that the cutting of Dura heads was a male activity. Likewise, when asked who transports the Dura to the threshing area, 90.9% said the female did, while the remaining said donkeys or family members were involved. The members referred to would have been exclusively female family members.

When considering the nafir labor time involved in the transportation activity, an average labor expenditure of 141 hours were allocated to bring in the harvest of sorghum during the 1984 period. This considerably understates the labor expenditure during a normal year. During 1984 the harvest of the far fields was completed by the second week in December. 1985 harvest continued into February. The difference was directly associated with below normal rainfall and reduced yields during 1984. The coefficients for labor allocated to the transport of sesame production would be approximately one third of that necessary for the transport of dura during 1985.

Comparison of the labor expenditure for transport of sorghum by human draft and that necessary using animal draft showed that a tremendous labor savings would occur. The average load of sorghum transported by an ox-drawn cart was 407.7 kg. The weight of Dura heads which could be carried by one woman participating in a nafir, averaged 14.4 kg per reika (a container made from wood and carried on the woman's head). The use of oxen resulted in a savings of 28.3 trips by women from the field to the threshing area for each trip made by the oxen. This was a labor savings of approximately 79 hours for each round trip made by the oxen. Similar coefficients would also exist for the transport of thatching, fuel, water, blocks for construction, rocks, and other commodities.

The producers were asked to estimate the labor costs in Sudanese pounds (US $1.00 = L.S. 3.55) and then to list in-kind payments made for labor. The estimated in-kind value was imputed through valuing the commodity cited by its farm-gate price. The producers reported that these costs amounted to a mean value of L.S. 83.

Producers in the 1984 experiment said they would be willing to pay a median value of L.S. 25 for the use of animal transport on a daily basis. This figure varied considerably depending on the quantity of sorghum produced by the farmer and thereby his need for transport. The mean value was L.S. 30.60. Validation of these rental figures during 1985 through the actual rental of the ox and equipment was undertaken. In Katcha the mean rental rate per trip to the field and back was L.S. 12. On a daily rental basis this ranged from a minimum of L.S. 5 to a maximum of L.S. 35. The L.S. 5 was associated with one trip moving blocks a short distance. The L.S. 35 resulted from the movement of three loads of dura from the fields to the threshing area. Normally, two operations would be undertaken per day but the inclusion of a third could be undertaken easily. The time associated with oxen draft for the larger rental revenue which included three trips was 6.5 hours or L.S. 5.38/hour.

Alternative Transport Uses for Oxen:

The participants were interested in using oxen for transporting different commodities. Table 4 provides a listing and relative importance of different transportation activities from 1984 results. During 1985 it was also learned that participants wanted to move building blocks and stone.

Transporting Dura heads, grass, and sesame occurs during a period from November through February. The transport of wood, water, blocks and stone occurs throughout the year. During the Kharief (rainy season) the use of draft oxen for transport would be curtailed due to mud and insect problems. This would restrict the use of oxen during a three month period, June through August.

The use of animal draft entails additional inputs both in the form of fixed and variable costs. Fixed costs would include training of the oxen, purchasing of oxen, if necessary, operator's labor (for the purpose of the analysis fixed at 135 days), ox cart, interest on capital, risk premium for use of capital, maintenance expense, cost of accessories, and depreciation expense. Variable costs would include supplemental feed and veterinary services. At maximum levels of management, a fixed cost for an animal shelter and additional variable costs for veterinary services and periodic vaccinations would be included. It was assumed that animal management would be less sophisticated than that recommended due to traditional husbandry practices.

The mean number of oxen owned by the producers and judged to be strong enough to carry out the transportation activity was .63. This low figure is a result of the small number of oxen which are kept for breeding purposes. Research undertaken by the WSARP technical staff suggests that herd composition for sedentary producers would include approximately 9.5% males, 2-4 years old (Bunderson, 1984).

The number of females which might be used for transportation purposes averaged 10% of the herd in this age group and the mean number of animals per household was nineteen. This varies somewhat from the figures which the producers reported with respect to male animals. Published figures

suggest that there are approximately 1.7 male animals per household, whereas producers in the sample reported .63 animals. Published and reported animal numbers per household are essentially the same, i.e., 1.7 and 1.9, respectively. This suggests that some producers would need to purchase oxen for the transportation activity or possibly combine a male and female animal in the team if they anticipated owning the package privately. While entrepreneurs could purchase the package for private use this was not the primary concern of the researchers. Notebook estimation would suggest that transportation activities would require only two or three ox carts per thousand farm households to meet most demand on a yearly basis. With this in mind, the program was oriented toward community ownership of the technology.

Cooperation Among Producers:

A tradition of cooperative labor activities exists within Kululu and other Nuba villages. This cooperation extends to many facets of social interaction. In order to investigate the possibility of cooperative efforts towards purchasing oxen and equipment, the producers were asked a series of questions.

Producers were queried as to whether any family members participated in cooperative efforts during the harvesting season. Table 5 summarizes their responses. During the sorghum harvest-season, male and female adults cooperate in the threshing activity. However, in other activities associated with harvesting, clearly defined divisions of labor exist, which compliment each other and result in a reduction of the total labor time spent harvesting.

The producers were asked whether of not they would participate in a cooperative ownership program. All of the producers interviewed responded affirmatively. The median number of people who would be considered for participation in a cooperative arrangement was five, the average 6.5. This is the maximum number of people in an ownership group with whom the respondents felt they could cooperate effectively. Of the producers interviewed, 75% reported they would pay for the cooperative purchase of animals for transportation. Four producers said they would pay an average of L.S. 54 for oxen. Furthermore, eight of the twelve respondents said that they would pay an average of L.S. 78 for the equipment necessary to utilize the technology. When asked what the total amount they would be willing to pay for the use of animal draft, the producers mean response was L.S. 122. This estimated total is consistent with what producers said they would pay for oxen and equipment when asked independent questions earlier in the questionnaire.

Many of the producers expected to use the ox cart for rental purposes to provide an additional income stream and to provide a service for individuals or cooperating groups. Of those interviewed, 75% said that they would provide this service.

Cultural Constraints:

During the 1984/85 cropping season a number on on-farm trials were carried out in Kululu by WSARP staff. These included variety testing, cultural practices, fertilizer response studies and others. On one occasion, metal markers which had been placed in the field were removed and in another case, farmers would not let oxen enter the cracking clay fields. Circumstantial evidence suggests that the first case may have been the result of intervention on behalf of the Kujur. The second case may have been due to reluctance on behalf of producers to have oxen or the metal cart in the field. This reluctance may have been either cultural or in anticipation of damage to crops caused by trampling.

In order to determine what affect the Kujur might have on the use of animal draft in Kululu, an investigatory question was asked, "Are there beliefs which preclude the use of oxen for transport of crops, residues, water or fuels?". In response, 83.4% answered the question as "No", while the other 16.6% said, "Yes", there are beliefs, and the Kujur would prohibit the use of oxen. A number of producers, who at first were very excited about participating, subsequently refused to participate without providing reasons for their decision. The same problem was not encountered during the 1985 trials. However, it is important to consider cultural influences such as that of the Kujur's when attempting to introduce new technology.

Women's Labor Input:

The movement of Dura heads, sesame, lubia and other commodities such as water, wood, and grasses is almost exclusively performed by women. In Kululu over 90% of the transportation of sorghum from the field to the threshing area is undertaken by women. One respondent moved Dura to the threshing area by donkey. Movement of threshed grain to the beit (home) was undertaken either by women, donkeys or camels.

A question then arises as to whether the displacement of women from nafir activities reduces incomes under their control. Whether or not this income is controlled by the woman after it has been earned is not clear. However, to the extent that payment is made in kind (i.e., sorghum) it would be consumed by the household. Thus, the benefit would accrue to the family just as it would if animal transportation resulted in freeing labor and reducing the need to supply food for nafirs.

The loss of income to women who participate in nafirs for transportation would affect the labor allocation within the household, assumed to be towards non-wage activities. Participants were asked what women would do to replace income they might lose from no longer participating in transportation activities. In response, 29% said that women would allocate their time to bringing water, 29% to bringing wood, an additional 12% would work in the Jubraka (house garden) or clean Dura respectively, while 6% would gather sorghum. All of these activities are productive activities which would increase the efficient functioning of the household. At the same time they are non-wage activities in the sense that the women are no longer receiving sorghum directly for their labor.

The ability of women to find alternative sources of income or for that matter, whether the opportunity cost for nafir work is higher than alternatives after a service has been performed, is unclear. A requirement of reciprocal work exists within the nafir activities as part of the farming system. If an individual organizes a work group for an activity, he/she may be required to reciprocate if people in the work group form their own nafirs at a later date. This reciprocity is partially based on the traditional values of the residents of the village and partially on the ability to pay for the nafir service. One is not forced to join a nafir. It may be that following the harvest of the household's crops, there is little interest on behalf of women to participate in additional work groups. The women may do so only to meet the requirement of reciprocity. If this is the case, then the opportunity to do work directly related to household maintenance and marketing appear to be the highest and best use of the females' labor given cultural parameters which exist. In this situation there is a net benefit to farm households which use the technology. The use of ox carts provides additional labor for other activities. Likewise, women's labor which was previously used in nafirs, could now be used in other activities which support the maintenance of the family unit, an integral part of the farming system.

Along this line of reasoning it is assumed that the women's labor no longer needed for nafir labor is a net benefit, rather than an opportunity cost associated with displacement from work-groups. The labor is not so much displaced as it is freed from the requirement of transporting grain. Therefore, it is included as a welfare gain for the community in the following analysis of benefits and costs.

Opportunity Cost of Freed Labor:

In order to estimate the acceptability of the technology for use in villages such as Kululu, Katcha, Bilenya, Sema and Kwiek an investment analysis of was performed. This included secondary welfare gains to both the community and to the households owning the technology. It was then broken down to consider both the repayment potential on the new technology and the benefit/cost ratios which prevailed under each situation.

The opportunity cost of freed labor was set at L.S. 1.32. per labor day (1 labor day = 1 man day = 1 woman day = 2 child days). This represents the average of nafir labor wage rates for the harvesting/transportation activity and the threshing/winnowing activity (Gillard-Byers and Azrag, 1985).

Rental Rates:

Rental rates for use of the ox cart service were based on the rate producers were willing to pay for transport of sorghum heads. The median rental rate for transportation on a daily basis was L.S. 25. This value was then used to impute a value to the movement of sesame. The valuation of grass was based on the nafir wage rate prevalent during the post threshing period. The intrinsic value of grass fluctuates in accordance

with its availability and demand. If it were valued on the basis of weight and market price of sorghum heads, the estimated value would be L.S. 0.03/kg. The price of a 15 kg bundle on this basis would be about L.S. 0.45 which, during the early post-threshing period would be smaller than its recorded market price of L.S. 0.50/bundle. As grass becomes scarce, the market price will rise and stabilize around L.S. 2.00/bundle, prior to the beginning of the Khareif (rains).

The value imputed to the labor freed from the collection of grass was an average of the two extremes in the market place, L.S. 1.23/day. The alternative, to value labor at the nafir wage rate, resulted in an average rate of L.S. 1.23/day, as well. This was the average wage rate over the year for work groups. The conformation of both the market and opportunity labor wage rate resulted from the declining value of labor during slack periods and the increasing market value for grass during periods of scarcity.

Table 6 provides information on the load capacity of ox cart and human transport and the expected rental rates. Given information in Table 6 and information about the number of trips which can be made daily, the labor days (LD) replaced by using the ox cart can be estimated.

The average number of trips that a woman can make to and from the field is about 2.15 trips/day. This is imputed on the basis of travel time to and from the field to the threshing area. Range/Livestock section data also supported this value (Bunderson, 1984).

Labor Coefficients for Periods of Activities:

The amount of labor savings which accrue to the village is dependent upon the activity, the timing of the activity and the complimentary or competitive nature of activities occurring at similar times. Three periods were defined. The first period of 30 days covered the harvesting of sesame in November. Period two, 60 days, covered the main harvest of sorghum from the cracking clay fields during December and January. Period three, 45 days, was allocated to the post-harvest collection of grass.

During period one, the sesame transport period, approximately 1,116 kg of sesame could be transported in two trips per day with the ox cart. This would result in an estimated savings of 28.8 woman days (WD) for each day of ox cart usage. Over 30 days this would save about 865 WD worth of labor previously used in transport.

Period two, transport of Dura heads would result in a savings of 26.3 WD per load transported by ox cart. Using the ox cart twice daily for 60 days would save approximately 1,577 WD of labor.

Labor savings during period three would be 18.7 WD for each day of ox cart usage. During the 45 days which the cart would be used to carry grass, approximately 837 WD of labor would be saved.

Assuming that the freed labor would be gainfully employed in other nafirs, marketing or other neglected activities, a net benefit would accrue from the freed labor. This labor savings would result in large welfare benefits for the community and would not necessarily relegate women to undesirable household chores.

Table 7 presents the benefits which would accrue to the community from freed labor being employed in other productive activities and those resulting from only 50% being gainfully employed. The total benefit figures in Table 7 represent intangible benefits within the context of this report because no money or product changes hands. However, if it is assumed that the women's labor is put to productive use, the labor saving during the period under study would generate L.S. 4,252.95 worth of additional output which would accrue to the household as well as the community. This would occur as a result of the value of services or commodities foregone, if the labor had been allocated to the transportation activity. If only 50% of the labor were employed at the nafirs' specified wage rates, the benefits would drop to L.S. 2,128.41. This assumes that freed labor is underemployed or that 50% of the WD saved are spent in unproductive leisure activities.

Returns on Investment in Transport Technology:

Table 8 presents a formalization of the material previously covered. The tabular analysis measures the benefits and costs associated with investment in ox cart technology. Initially, all revenues under consideration are generated from the use of ox carts through rental. Welfare benefits, found in Table 7, are included in the second part of the analysis.

Fixed Costs:

The introduction of the ox cart technology entails expenditures on behalf of the household. Equipment including ropes, traction chains, yokes and other accessories must be purchased. The training of operators, interest expense, and depreciation on equipment must be considered as fixed costs associated with the investment.

Capital equipment and animals are the largest expenditure. The ox cart by itself costs L.S. 432 and with the necessary accessories, the cost increases to approximately L.S. 476 (NMRDP, 1984).

Oxen costs depend on the status of livestock sales in the market. Prevailing prices for oxen during 1984/85 were approximately L.S. 125/AU. The prevailing market price of L.S. 125/AU was used in this analysis. Depreciation was charged over 10 years for equipment using straight line scheduling. A salvage value of L.S. 100/pair of animals was imputed with oxen depreciated over five years. Interest was charged on the ox cart and accessories at 25% of the original balance per year, over the period that the loan is outstanding. A risk premium of 20% to account for producers' risk aversion was also charged against the capital outlay. It was assumed that the loan would be paid off in three years for the ox cart and the loan for animals, during the first year. A 10% down payment requirement for

purchase of an ox cart and a 30% down payment for purchase of oxen is charged. A 10% insurance charge for replacement animals if one or more should die was associated with purchase of oxen from the Nuba Mountain Rural Development Project .

A maintenance cost for equipment and oxen was charged to insure capital availability for minor problems. Spare parts, to insure against any extensive down time were estimated at 25%.

Trainer's labor was valued at the NMRDP daily wage rate of L.S. 3.00/day. The trainee's labor was valued at the nafir wage rate of L.S. 1.23/day which would prevail at the time of training. The operator's labor was valued at L.S. 1.23/day, which is the nafir wage rate during harvesting, threshing, and winnowing.

Variable Costs:

Two variable costs, suggested by the animal traction specialists, might be incurred by producers. These are supplementary feeding and veterinary costs; the former representing the greatest expense.

RESULTS:

Two aspects of the budget for the introduction of ox carts for transportation are of interest. The first is the potential for producers or village cooperative which own ox carts to market that service and generate rental income large enough to cover their fixed costs and variable cost during the first three years and their variable costs after that time. The second aspect is the welfare benefits which accrue to the household and the community in the form of additional labor availability for other productive enterprises.

The preceding analysis provided benefit/cost ratios for rental of ox cart technology and opportunity money values for freed labor. The total value of freed labor is estimated to be L.S. 4,252.95 per 135 day harvest period, although some of this value may not be realized until after the period is over. If only 50% of the labor were utilized productively, the value would be L.S. 2,128.41. It is difficult to estimate how much of the freed labor will be employed in alternative activities or simply used in unproductive leisure time, if unproductive leisure time indeed exists.

The rental of ox cart services would generate revenues of over L.S. 3,500 during the 135 day period if used at two thirds capacity. Total costs would vary over the first three years due to the repayment of loans. These costs range from L.S. 1,443 in year one to L.S. 697 in year five. The benefit/cost ratios increase from 1.46 in year one to 4.10 in the fifth year when all costs are incurred and only rental benefits are considered.

In many cases, producers would be able to supply oxen themselves. Under these conditions the benefit/cost ratio in year one would increase to 2.31. Average benefit/cost ratios for the five year period would be 3.24 and 3.41 for those purchasing oxen and those supplying their own, respectively.

If the welfare benefits which accrue to the community are included with rental benefits, the resulting benefit/cost ratios range from 4.41 in year one to 10.19 in year five assuming that all freed labor is reemployed in other work during the 135 day period. If 50% of this labor is unemployed, the ratios range from 2.94 in year one to 7.15 in year five.

The new technology appears to be recommendable based only on the benefit/cost ratios resulting from consideration of rental benefits. One must remember, however, that the primary uses suggested by producers for the technology included the movement of Dura stalks, water, blocks and wood. Rental benefits from these activities, three of which do not necessarily compete directly with other production activities, would result in substantial increases in rental benefits.

If welfare benefits, due to the labor savings associated with the movement of additional commodities are included, the ratios would continue to increase above those estimated. Data is unavailable to estimate what these might be over an entire year. Moreover, the introduction of improved animal husbandry practices and use of animals for transportation could lead to a necessary transfer of knowledge capital. The training of producer operators in 1985 to work with oxen resulted in a producer more prepared to accept the use of cattle for traction activities.

At the present time, women living in villages of the Nuba Mountain area perform back breaking transportation activities every day. During times of water scarcity, which occur in the dry season each year, they may leave their beit before sunrise to travel 10 to 20 kilometers to collect water. They are capable of hauling approximately 15 kg of water in one trip. Therefore, they may be required to make an additional trip in the evening. This, in addition to other household and production activities, is an amazing feat. Labor savings from the introduction of animal draft for transportation would reduce the time necessary to undertake activities of this sort.

The success of the introduction of animal draft requires available capital as well as peoples willingness to participate. The total revenue which would have been generated during the 1985 experiment in Katcha, Sudan if animals had been used twice a day would have been approximately L.S. 3206. This is L.S. 349 less than what was estimated from 1984 experimental results. According to technicians' reports the experiment did less well in Katcha than it did in Kweik. Additional costs were incurred during the 1985 experiment associated with the hiring of a cowboy for grazing the cattle and a gaffir (guard) for protecting the animals during the night. The majority of these costs would not be incurred under normal circumstances because the animals would be included within the herd of the operator.

RECOMMENDATIONS:

The Nuba Mountain Rural Development Project located in Kadugli, Sudan, should investigate the possibility of ox cart sales without required purchase of other implements. At the present time, a producer purchasing an ox cart must first purchase, as a minimum, a Nuba hoe. This adds considerable additional investment costs and is only useful during a short period of the year.

An estimation of the optimal number of ox carts needed to service a village should be undertaken, to prevent an initial over supply of the technology in the market leading to marginal returns being less than marginal costs for rental activities.

The Agricultural Bank of Sudan should provide credit for individuals as well as cooperative groups of producers to purchase ox carts. This should be done through the Nuba Mountain Rural Development Project in cooperation with the WSARP. Communities targeted should be those already identified and introduced to the concept of ox cart transportation. This should be carried out with express purpose of developing revolving credit programs financed with local capital.

Benefit/cost ratios suggest that the technology is recommendable. Cooperative efforts on behalf of the Extension Department, the Nuba Mountain Rural Development Project, the Regional Ministry of Agriculture, and the agricultural Bank of Sudan should be made to extend this technology to producers in other areas. Target areas should be those areas where the use of cattle for traction or transportation activities has not been previously undertaken. This will provide a knowledge base for the future introduction of traction activities and reduce investment costs for future implement purchases.

Further research should be undertaken to verify results of this study. Specifically, the following activities should be undertaken:

1) Placement in Nuba Mountain area villages of oxen and carts for the express purpose of a rental service. The rental fees should be determined in the market on the basis of demand for the service. Rental fees should be paid either in money or in kind.
2) The technology should be available in villages for the entire year to determine the time, type, and quantity of activities which the individual or community undertakes to verify results of the three year program.
3) Formal identification of alternative employment and the value of alternatives for women's freed labor should be undertaken. This would provide a basis for assessing changes in the quality of life experienced by women whose labor may be allocated to other activities or leisure.

SUMMARY:

During the 1982-83 cropping season the Range/Livestock section of the Western Sudan Agricultural Research Project undertook researcher-managed on-farm trials with sedentary producers the villages of Kululu and Bilingya, Sudan. The experiment was undertaken to evaluate the potential for introducing ox-drawn carts into the Nuba farming system. The rationale for the experiment was that animal draft would reduce labor constraints associated with cropping activities (Bunderson, 1984). With the arrival of the agricultural economist in 1984 a decision was made to organize a collaborative effort between the Range/Livestock and the Socioeconomic Sections.

Based upon previous experimental results the program design was modified to focus upon the use of ox-carts for the movement of grain from field to threshing area. The village of Kululu was chosen as the site for the experiment during the 1984-85 period. A major objective of this experiment was the collection of information detailing preferences and anticipated uses of the cart as well as generating data which supported or discounted previous Range/Livestock section findings.

Subsequently, the program design was modified a third time on the basis of 1984/85 results. These modification were introduced during 1985/86. At the time of the 1985/86 cropping season the experiment had moved from researcher managed experimentation through a researcher/farmer managed phase to a completely farmer managed stage. The program on the other hand had been modified from experiments dealing with traction as well as transport activities to the transport of specific commodities from the field to threshing area. Subsequently, during year three, the program was transformed into a village level credit program. Only partial results were available from year three. These results appeared to support previously estimated coefficients. However, no information was available on the capability of the council of Sheiks to oversee a village level credit program. With continued support from the Nuba Mountain Rural Development Project and the WSARP it should be possible to implement prototype village credit systems in Katcha and Kwiek, Sudan over the next two years.

Flexibility in program design and implementation provided options which would not have existed otherwise. Adaptive research utilizing on-farm trials provided a basis for developing credibility and focus with respect to farmer wants and needs. Incorporation of previous research findings allowed the design, implementation and partial evaluation of a technological package in a three year period.

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Table 1. Settlement by Type of Site (Comparison of Two Surveys)

Type of Site	Formal Survey (n = 111)	Jubraka Survey (n = 31)
Hillside (hilltop, hillside and foot of hill)	82.2	91.8
Plain Settlement	15.7	0.0
Ridgetop	1.9	8.2

Source: Abu Sabah. 1985. WSARP Pub. No. 42.

Table 2. Household Composition (Comparison of Two Surveys)

Type of Site	Formal Survey	Jubraka Survey
Avg. Household Size	6.98	5.15
Avg. No. of Adults	3.06	3.01
Avg. Family Labor Available at Home and Capable of Fieldwork	2.99	5.10
Avg. No. of Children	3.92	2.87

Source: Abu Sabah. 1985. WSARP Pup. No. 42.

Table 3. Jubraka Management by Sex

Sex Category	Jubraka Survey
Men	25.8
Women	51.6
Joint Mangement	22.6
	100.0

Source: Abu Sabah. 1985. WSARP Pub. No. 42.

Table 4. Operations Which Would be Undertaken if Animal Transport Were Available

Commodity to be Transported (% that would transport)		Commodity to be Transported (% that would transport)	
Wood	100	Water	50.0
Dura Heads	91.6	*Dura* Stalks	33.3
Grass	75.0	Peanut Hay	8.3
Sesame	58.3		
1985: Construction Blocks Stone			

Table 5. Cooperative Activities Undertaken During the Harvest Season

Adult – Male	% Coop.	Adult – Female	% Coop.
Cutting *Dura* Heads	91.6	Transp. *Dura* Heads	83.3
Threshing	75.0	Threshing	33.3
Collecting Lubia	8.3	Collecting *Dura*	16.6
Child – Male		**Child – Female**	
Keeping Animals	33.3	Transp. Harvest	16.6
Bringing Water	8.3	Child Care	16.6
Collecting Lubia	8.3	Bringing Water	8.3

Table 6. Load Capacities and Rental Rates for Transport Activities

Commodity	Ox Cart kg/load	Human kg/load	Rental Rate L.S./day	
			Estimated (1984)	Actual (1985)
Dura Heads	407	14.4	25	24
Sesame	508[1]	18.0	34	30
Grass	300	15.0	23	
Blocks				15

[1]Imputed on the basis load capacity for sorghum. The bulk and density of the commodity are factors which determine quantities that can be transported.
Ox carts are specified to carry up to 1,000 kg.

Table 7. Community welfare benefits from Freed labor

Benefits Opportunity Field Cost of Freed Labor			Years 1 - 5 100% labor utilization	Years 1 - 5 50% labor utilization
Commodity Transported				
Sesame:	Amount	(WD)	865	433
	Value	(L.S./WD)	1.32	1.32
	Total	(L.S.)	1,141.80	571.56
Dura Heads:	Amount	(WD)	1,577	789
	Value	(L.S./WD)	1.32	1.32
	Total	(L.S.)	2,081.64	1,041.48
Grass Straw:	Amount	(WD)	837	419
	Value	(L.S./WD)	1.23	1.23
	Total	(L.S.)	1,029.51	515.37
Total Benefits		(L.S.)	4,252.95	2,128.41

FIGURE 1: SUDAN

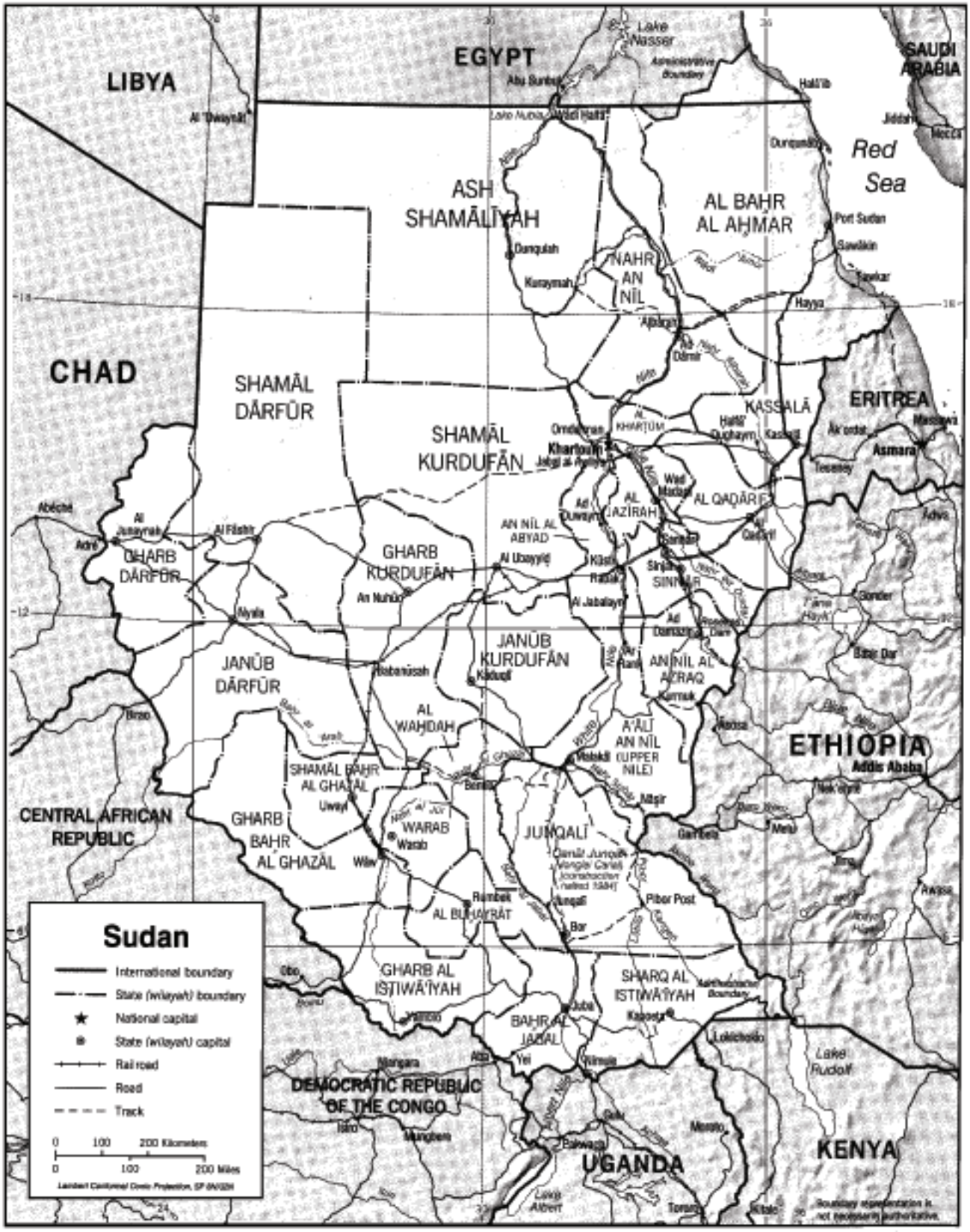

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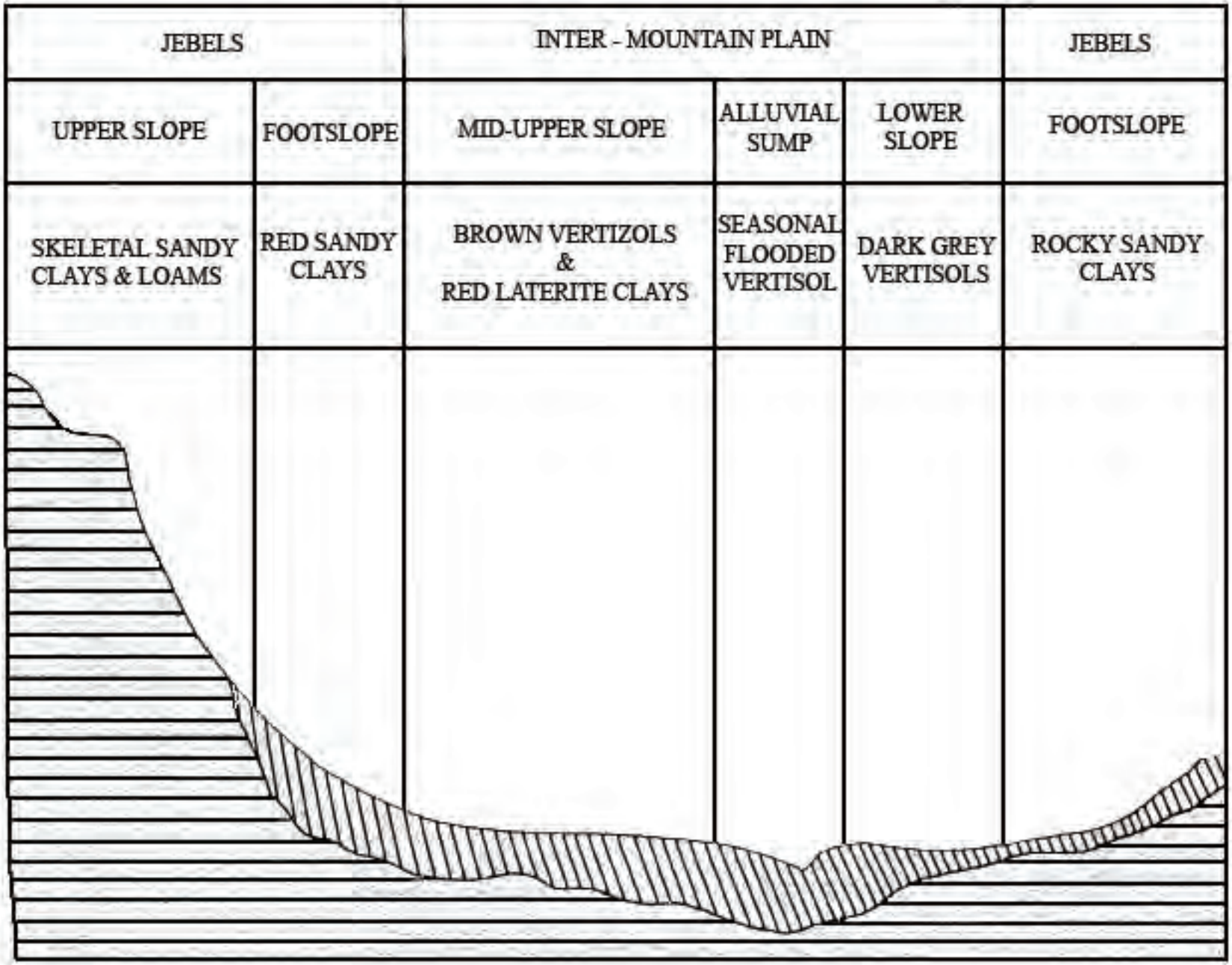
FIGURE 2: SOIL TYPES ACCORDING TO LANDFORM IN THE NUBA MOUNTAINS



ON-FARM TESTING OF IMPROVED TECHNONOLOGIES IN SOUTHWESTERN NIGERIA: THE IITA EXPERIENCE

M.C. Pa1ada, W.O. Vogel ; and H.J.M. Mutsaers, Fa rming Sys tems Prog ram

INTRODUCTION

The Farming Systems Program (FSP_ at the International Institute of Tropical Agriculture (IITA) was established and has been in existence for 15 years. During the early years the main emphasis of research was focused on environmental characterization and analysis of the farming systems in the humid and sub-humid regions of West and Central Africa and on the development of crop and soil management techniques suitable for those environments and systems. After 10 years of cropping systems, crop and soil management practices and small farm tools that are ready, either for direct transfer to farmers or for testing under farm conditions. This development has led to the formation of on-farm research (OFR) within the Farming Systems Program.

On-farm research is now an integral part of the Farming systems Program and has been operating for the last 4 years in collaboration with the national research centers, extension and development agencies. Its activities are focused on 3 broad objectives: 1) development and testing of OFR methods adapted to the farming systems of the humid and sub-humid regions of Africa, 2) dissemination of these methods through training and cooperation in OFR programs of national agriculture research centers closely associated with IITA and 3) testing of IITA technologies under farmers' conditions in a range of ecologies and systems assessing their adaptability and identification of new research needs. These objectives are interrelated and overlapping since the development of OFR methods requires improved technologies for on-farm testing while testing of new technologies requires sound research methods. Moreover, training and cooperation with national programs require both.

ON-FARM RESEARCH APPROACH

IITA's on-farm research program follows a generally accepted principles of farming systems research consisting of several phases, that is, selection of pilot research area, description, diagnosis and identification of target groups or recommendation domains, design and choice of test technologies, on-farm testing and ecaluation, and dissemination through pilot extension program (Zandstra, et al, 1981: Norman, 1982: Hildebrand Poey, 1984).

In most West African countries considerable data on description, diagnosis and design components are already available, but field experience in on-farm experimentation and extension is till limited. The successful completion of the full cycle up to the point where new technologies identifies and "fine tuned" through on-farm research, are actually adopted by farmers, is the only evidence to prove that the OFR approach is a step forward from conventional extension method.

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UTA ON-FARM RESEARCH PILOT AREAS

For the past 3 years the/OFR activities had been focused on training, organization, diagnostic surveys, description and establishing on-farm research pilot areas. Prior to the establishment of OFR pilot areas the IITA socioeconomic unit has done some on-farm research in selected villages in Nigeria through specific surveys and case studies (Ay, et. al, 1983; Ngambeki and Wilson, 1984; Ashraf, et al, 1985). These studies provided useful background information and guidelines for the current on-farm research project. The present OFR team has set up 3 pilot research areas in Nigeria in cooperation with national research institutes and extension programs. These sites are set up in several locations covering the forest (Ayepe), savanna (Bida) and forest-sayahna transition (Alabata/Ijaiye) zones (Fig. 1). These sites are representative of the major of the agroecological zones of the humid and sub-humid regions of West and Central Africa. In each of these pilot areas the OFR activities follow a full cycle of exploratory surveying, technology testing and pilot scale extension. A wide variety of technologies both originating from IITA: and elsewhere are considered for testing in order to develop suitable testing, monitoring and évaluation techniques. Several objectives are pursued in these pilot research areas. The OFR team has the opportunity for testing appropriate technologies under real conditions and developing on-farm research methods while at the same time enhancing the team's capability in training national research and development staff to set up their own OFR programs.

The major content of this paper deals with on-farm research activities in the forest-savanna transition zone of southwestern Nigeria.

RESEARCH SITE DESCRIPTION

The OFR site in the forest-savanna transition zone is located in Akinyele Local Government Area of Oyo state (Fig. 2). The area is within 20 km from urban centers of Ibadan and Oyo and is accessible .through a secondary road even during the rainy season. Most rural people belong to the Yoruba tribe and the village are ruled by a chief. A two-week exploratory survey was conducted by a multidisciplinary team November 1984. The survey provided useful information which guided the OFR team in planning and implementing on-farm testing program (Palada, et. al, 1985).

Physical and Bioagricultural Environment

Climate and vegetation

The area receives an annual rainfall of 1200 mm distributed in bimodal pattern 9Fig. 3). This results in 2 cropping seasons. The first season starts in late march and ends in July covering a period of 120-135 days. The second season extends from late August into late October, a period of 60-70 days. The variability of rainfall is shown in Fig. 3 using the 25,

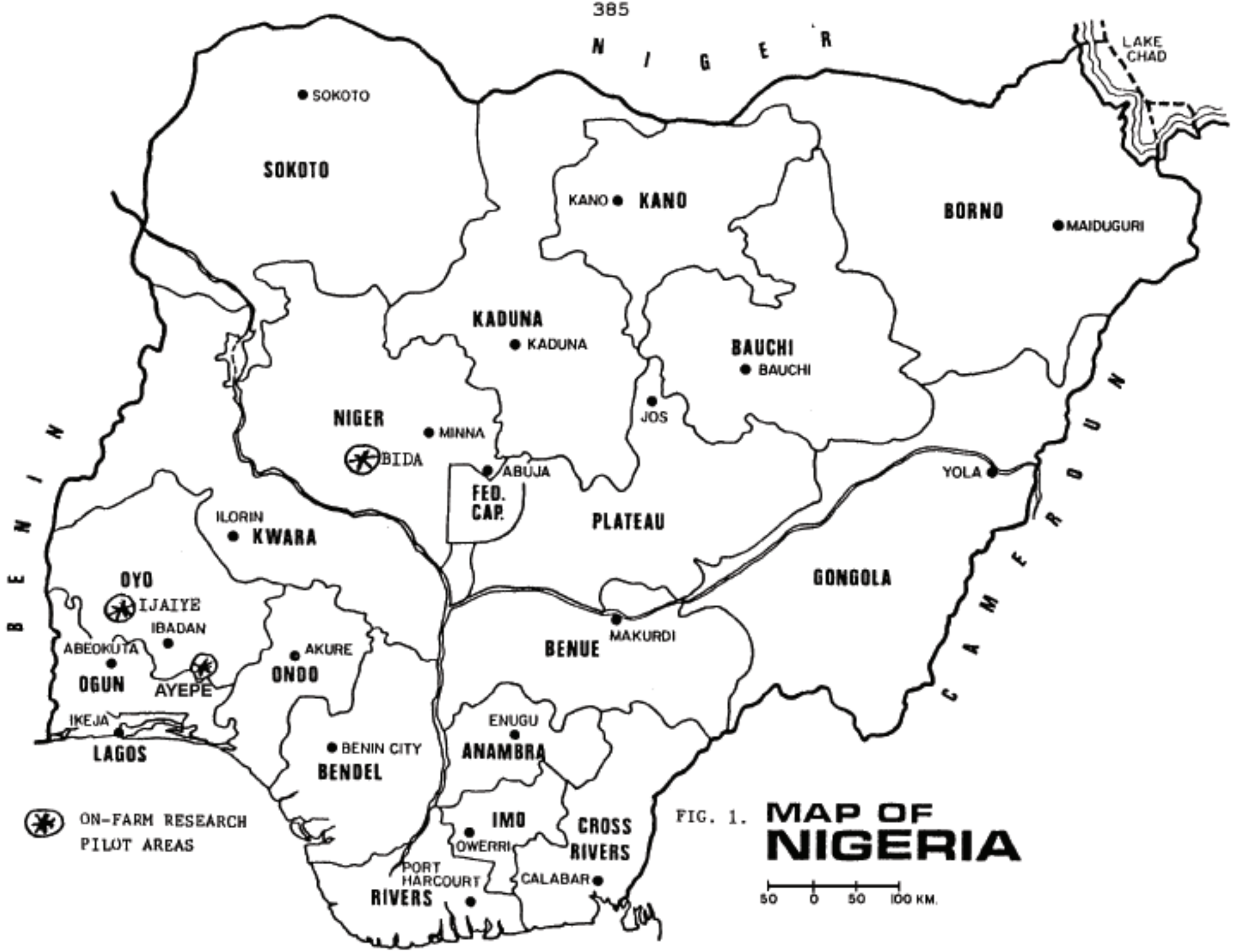

FIG. 1. MAP OF NIGERIA

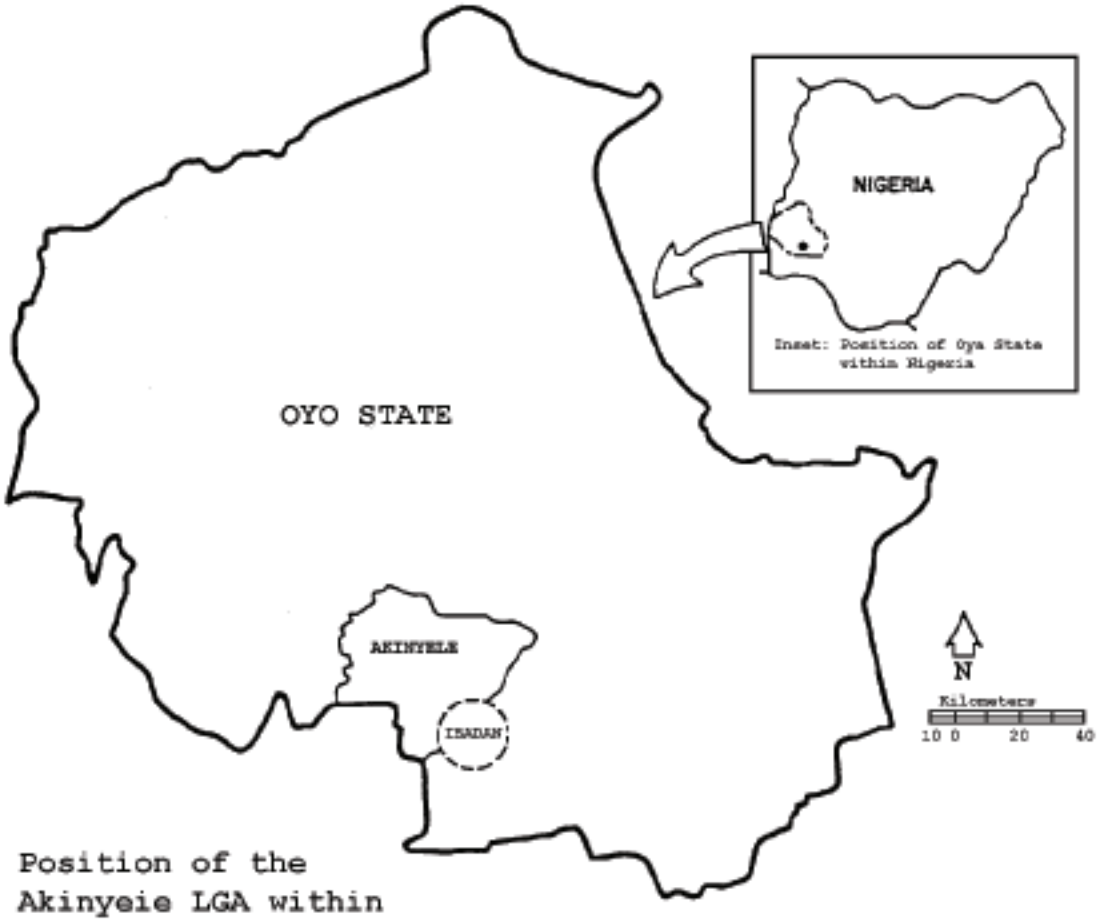

FIG. 2

Map 1. Position of the Akinyeie LGA within Oya State

for 10-day totals. For many crops severe moisture stress sets in after 10 days. The 25 percentile indicates that for 5 in 20, years, rainfall is expected to fall below this line. Thus, the line is a crude measure of risk. For maize, Fig. 3 indicates that the first season is long enough for a 120-day variety to mature. Planting may commence as early as late March, but is risky even until late April. The second season rainfall is short and erratic. Crop establishment is a problem in late August to early September. Erratic rainfall at the end of the second season sometimes results in crop failures. This implies that farmers face greater risk when they grow second season maize.

The area lies on the boundary between lowland rainforest and the forest savanna mosaic of northern Oyo state. As more forest areas are cleared the land under savanna will expand. In each village, fields are distributed between “savanna” and secondary forest.

Soils

Soils in the area are sandy and derived from southern basement complex. Major soils belong to Apomu, Egbeda and Iwo series in the order of Entisol and Inceptisols. Generally, soils of this type have low inherent fertility.

Land types and utilization

Three major land types can be distinguished according to their position in the topography, viz. hillcrest and upper slope, middle and lower slope and valley bottom. Villages are often located on hillcrest and surrounded by belts of secondary forest. Cocoa, coffee and cola are found in these belts. The major food crops are grown typically sandy soils of gently sloping land behind the forest. Some of the valley bottom land lends itself to dry season vegetable production.

Crop, cropping patterns and crop sequences

The principal crops in the area are maize, cassava and yams. Vegetables such as tomato, pepper, okra, cowpea, amaranthus, celosia, garden egg, etc. are considered minor crops, but may contribute significantly to cash income. Bananas and plantains are grown sparsely while citrus, mango and oil palm are found on field edges. The basic cropping patterns and crop sequences are presented in Fig. 4.

The maize+cassava intercrop is most frequently planted in the first season (Pattern 1). The intercropped cassava is harvested towards the end of the first season of the following year. The next maize+cassava will be a late season crop planted in August. With maize+cassava planted in the second season (Pattern 2) the cassava will be harvested at the end of the

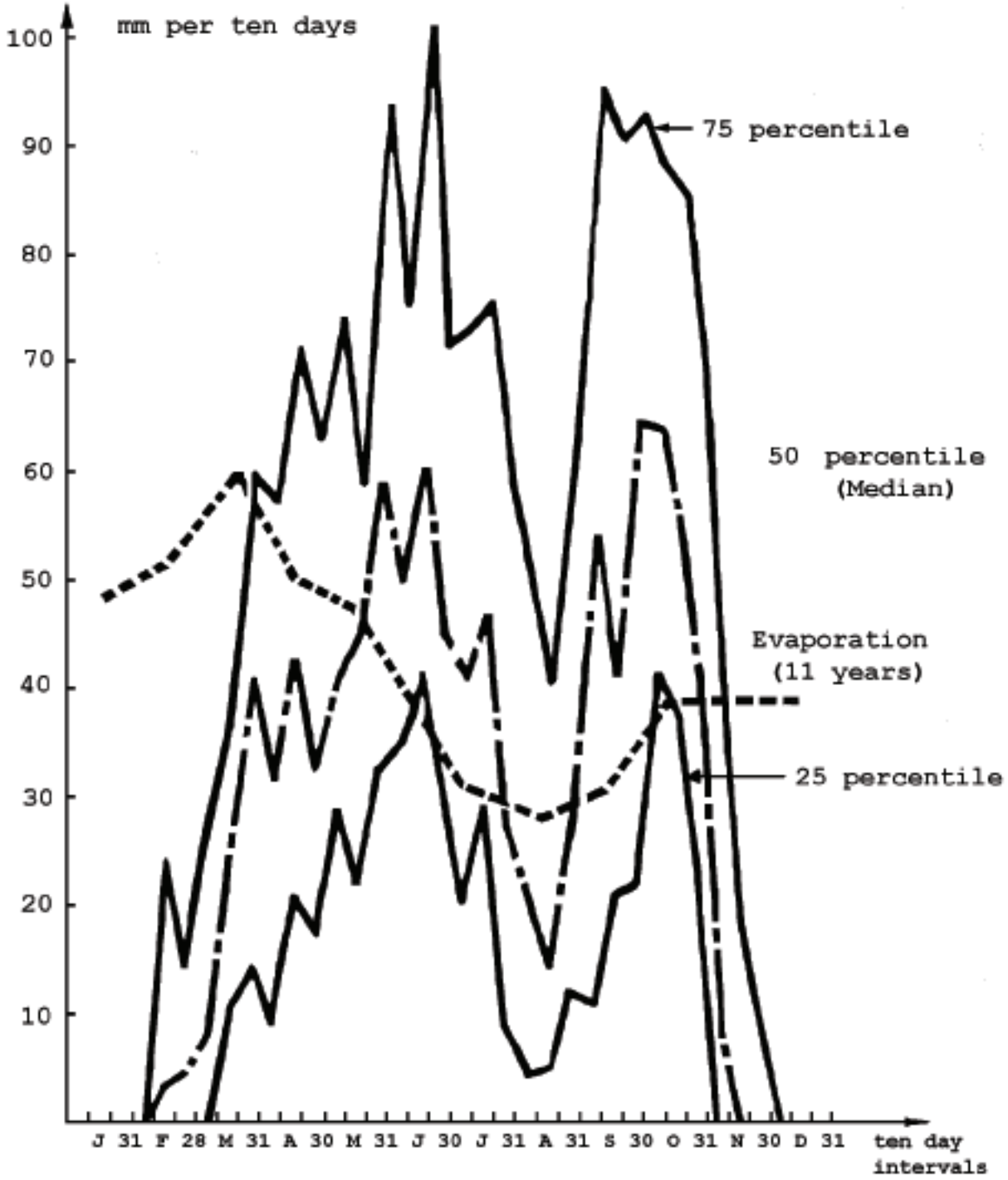

Fig. 3 Rainfall pattern of Ibadan showing the 25, 50 and 75 percentiles at 10-day period. (Univ. of Ibadan, 20-yr. average)

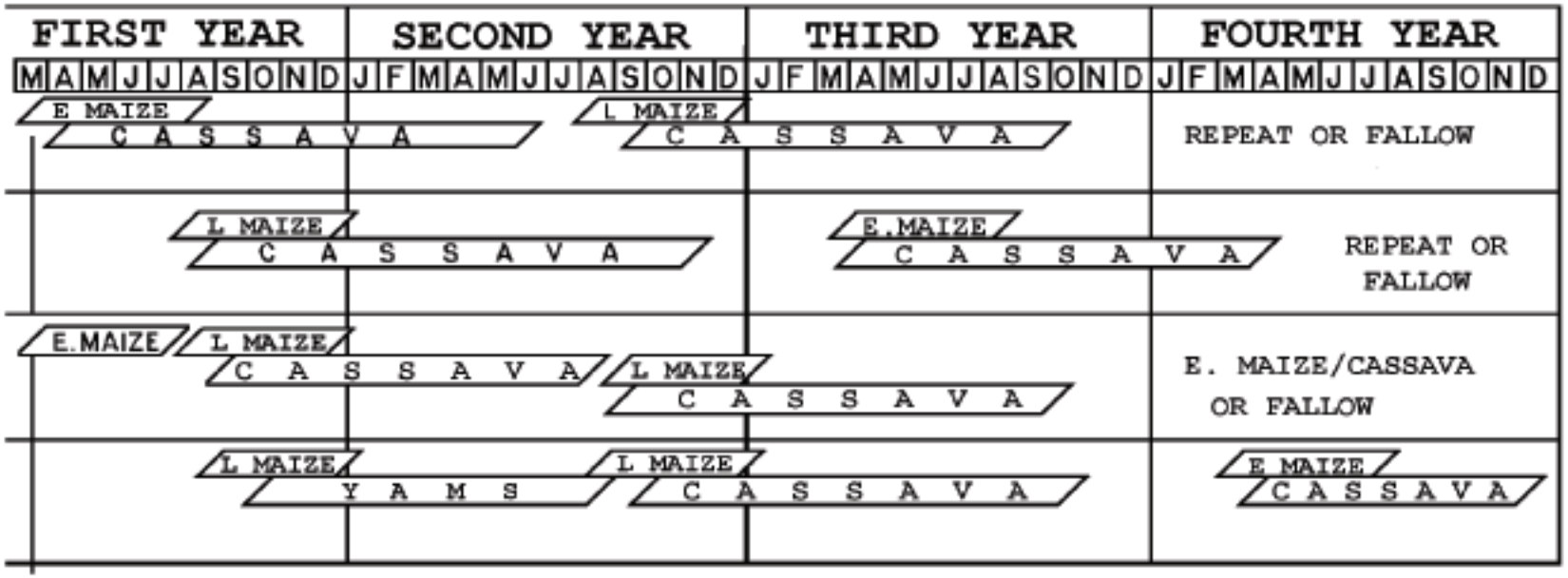

Fig 4. MAJOR CROPPING SYSTEMS AND ROTATIONS IN IJAIYE (DERIVED SAVANNA

second season of the following year. Thus, the next maize+cassava crop is planted in the first season of the third year.

In the maize+cassava intercrop, cassava is normally planted slightly later than maize. Maize+cassava intercrop is a good combination because of crop complementarily in growth patterns. Maize is the stronger competitor and completes its cycle without interference from cassava, while the latter takes off rapidly after the maize is harvested.

Yams are planted in the beginning of the dry season (November) and are relayed into late maize and/or vegetables or they may be planted on newly cleared land (Pattern 4). The yam will sprout with the first rains of the following year. There are some indications that slightly gravelly soils with loamy or clayey subsoil are preferred for yam growing.

Although the patterns in Fig. 4 are the basic ones, they are by no means the only ones occurring. Other sequences can, however, be looked as variations of this basic scheme.

Occupational period and fallow

Most villages have fields in the derived savanna as well as in a more forest like environment. Farmers generally own 2-4 separate food crop fields with sizes ranging from 0.5 to 5.0 acres each. The number and size of fields owned by women are generally small. A majority of the fields are of the maize+cassava types (Patterns 1-3).

Savanna fields are generally cropped for a longer period than forest fields and fallows are short duration. Cropping systems in the savanna field, therefore, relies on the use of fertilizer and possibly on regular ‘cassava fallows’. Generally, such fields are used for 4 to 5 years and fallowed for 2-3 years.

Forest fields are occupied for shorter periods and the intended fallow is longer, however, there is a trend towards more intensive utilization. Although some of the forest fields presently cropped had fallows of up to 10 years before clearing, most farmers stated that the next fallow would be in the order of 304 years. Occupation is also extended by the use of fertilizer after the first year or two. These trends may lead to further ‘savannafication’ of the forest patches.

An important impediment to longer occupation and shorter fallow is the encroachment of grassy weeds. In the savanna fields, tractor plowing is used as a remedy, possibly with deleterious effects in the longer run. Difficult accessibility of the forest fields and shortage of tractors has so far restricted this development.

Land preparation and sources of seeds

Two systems of land preparation are common in the area. Forest land is cleared by slashing and burning, sometimes followed by destumping. All operations are performed manually from November to January. Farmers then make ridges or mounds using hoes. The mounds are rebuilt or moved around during the following years. In savanna fields, grasses and shrubs are slashed and burned before tilling. If available, tractors are used for plowing and harrowing. Farmers may make ridges or mounds, but often plant on flat when tractors are used.

Planting is done manually and starts after the second heavy rainfall in March and may continue until May. A cutlass is used to make holes for planting maize and cassava. Hoes are used for planting yam and covering the seed with soil. Seed and other planting materials are usually kept from previous harvest. Sometimes they are obtained from neighbors or purchased in the local market. Demand for improved varieties is high.

Soil fertility maintenance

The bush fallow system is till the most important means to restore and maintain soil fertility. After 3 or 4 years of continuous cropping, nitrogen becomes a limiting nutrient especially on more sandy soils and where weed infestation is high. When fertilizer is applied to maize, the usual rate is 1-4 bags of 15-15-15 or calcium ammonium nitrate per acre. There is no evidence of farmers using organic fertilizers. Crop residues and animal manures contribute very little to soil fertility maintenance. Farmers continue cropping until soil nutrients are deplete and crop yields are low.

Weed, pest and disease control

Major weeds in the savanna are grasses and sedges. The most serious weed is spear grass (*Imperata cylindrical*). Hand weeding using hoes and cutlass is the only method on control. In the maize+cassava systems at least 4 weedings are required whereby the first 2 is intended for maize. The weeds are used for mulch and ground cover. Crops are exposed to pest at any stage between planting and consumption. Even weeds are perceived as a problem; farmers rarely know ways of controlling them. Most destructive pests in maize are stemborers, earworms and termites during the growing period and variety of other insects during storage. Maize steak virus causes heavy losses especially in the second season. Cowpeas have almost disappeared from the area due to aphids, thrips and pod borers. Green spider mite, mealy bug and grasshoppers attack cassava.

Harvesting and processing

All harvesting and processing is done by hand. The women carry most of the produce to the village on their heads. Farmers may sell whole fields to traders. Harvesting is then done by a crew of hired laborers and transported by truck.

Livestock

Small ruminants (goats and sheep) and chickens are raised by each farm family. The women usually maintained the livestock. The animals are free to roam in and around the villages within a grazing belt of between one and two kilometers. No crops can be grown with in that area. The survival rate of lambs and kids is low due to pests des petites ruminant (PPR). Livestock activities are not integrated into the cropping systems.

Socioeconomic Influences on the Farming System

The oil boom in the late 1970s and the depression of the 1980s had a marked influence on the farming system. The boom led to an outmigration especially of young males from the rural areas which increased the importance of women even more. Agriculture in general was neglected. The few attempts to increase output focused on input subsidies. The boom left behind a transportation system which, by African standards, is excellent. The depression has created a positive climate for a reorientation of agricultural policy towards increased food crop production.

Land ownership follows customary law. Land is considered family property. It cannot serve as collateral. This is an obstacle to the development of rural credit system. Holdings range between 2 and 10 ha. Most farmers own land in the savanna as well as in the forest. Two groups fall out of this pattern. A considerable number of farmers own only forest land. This land is difficult to access by road. Thus, use of tractors is impossible. Women form the second group. Although many women own and farm land the size of their farms is smaller compared with me.

The agricultural credit system is underdeveloped. In many villages farmers have organized credit cooperatives. Members have to buy shares. They may borrow twice the amount of their contribution until harvest time.

There are clear divisions of labor within the household and for farm work between mean and women. Women are expected to perform the household chores. Men do the heavy field work like land clearing and heaping. However, women perform the equally heavy transportation at harvest. Processing the marketing is dominated by women. Hired labor is employed during the peak seasons of land clearing and weeding.

Delineation of Target Groups

Two target groups were identified based on location of fields and farm size: farmers whose land is mostly in the derived savanna farmers' and farmers, whose fields are in the forest, 'forest farmers'.

Savanna farmers have larger cropland areas. A considerable number of them have access to tractors. Most of them use tractors because their fields are inaccessible and could not be plowed because of the stumps in the ground. The do not use fertilizer and fallow periods are longer. Both groups were found to grow the same crops. More weeds are found in the savanna fields. This may be due to shorter fallow periods. It may also be that savanna farmers who do not face such land clearing costs tend to spread the scarce factor, namely labor, over a larger land area, while forest farmers who have higher land clearing costs tend to save land and thus weed more intensively.

Assuming that family size is the same for both groups and that yields are about equal, income and the surplus free for capital formation can be expected to be larger for savanna farmers. This suggests the following: technologies which require higher capital inputs and more cash outlays may be more feasible for savanna farmers. Also, this group can be expected to be less risk averse because of higher income. Low input technologies associated with low risk may be more feasible for forest farmers.

Women may constitute a third target group. Women have to spend more time on house hold activities for which they are not paid. On the other hand women control the marketing and processing activities. It is not clear whether they have more cash than men. Women were found to rely more on hired labor for their farming activities which requires cash. It is doubtful whether they have same investment opportunities in farming as men.

Certain problems are common to all target groups and the same solution would apply to all of them, they are 'group neutral'. An example is maize streak and the use of resistant varieties. Other problems are specific to certain groups, for example spear grass infestation is only severe in savanna fields. An appropriate solution maybe different for larger farmers who can afford higher cash outlays (herbicides?) than for smaller farmers (fallow cover crop?).

Besides the use of different innovations for different target groups in some cases, the groups should be used for stratification of the trial for any type of intervention.

Ranking of Constraints

An exhaustive list was prepared of constraints confronting farmers and under-utilized opportunities. The team made a preliminary selection and ranking of those which they considered as the major ones and analyzed farmers own solutions to the constraints. Some of these major constraints are addressed in a first set of on-farm trials. Below is a list of the major constraints ranked according to their assumed importance and farmers' own solutions :

Constraints	Farmers' solutions
I. Technical	
1. Low inherent soil fertility and inadequate fertility maintenance	Use of fertilizer, fallow, cassava "semi-fallow", mounding(?)
2. Erratic late season rain and non-adapted crops and varieties, leading to crop frequent crop failure in late season	Growing of early maturing vegetables, limited maize growing
3. Build-up of weeds over the years (forest and savanna) and predominance of difficult (grassy) weeds in savanna	Tractor plowing (savanna), herbicides (limited), early weeding
4. Grasshoppers on cassava	Choice of variety, destroying of breeding sites with gammalin 20
5. Maize streak virus	Not generally perceived as serious problem
6. *Low yield potential of local crop varieties? (Table 1)	
7. *Under-utilization of valley bottoms?	
8. Cowpea pest complex	Give up cowpea growing

*Constraints with an asterisk are uncertain and more information is needed.

Constraints

II.	Socioeconomic	Farmers' solutions
1.	Shortage of labor for land Preparation and weeding	Hire labor, limit cropped area, substitute less labor requiring crops for yam, use herbicides, exchange labor(?)
2.	Lack of cash and credit	Formation of cooperatives, sale of land, off-farm enterprise, adjust harvest of cassava to cash needs, remittance by absent family members, sale of livestock
3.	Weak inputs supply and extension services	Buy inputs (fertilizer) by piecemeal in odd places

Choice of Technology

After ranking the major technical constraints, the OFR team organized a discussion meeting with individual commodity or crop improvement programs and scientists from Farming Systems Program. The purpose of this meeting is to identify and select technologies the commodity programs can offer to address farmers' constraints. The result of this meeting indicated that some technologies are ready for on-farm/farmer managed trials, but others require more verification tests under farmers' field conditions. The following technologies were selected and matched against the major constraints for on farm testing:

Constraint	Technology
1. Low yield potential of local varieties	Improved maize and cassava varieties
2. Low inherent soil fertility	Fertilizer, alley cropping
3. Erratic late seasons rains and non-adapted crops	Short maturing maize, cowpeas and soybeans
4. Maize streak virus	Streak resistant maize
5. Cowpea pest complex	Integrated pest management

Table 1. Average yield of major field crops in Ijaiye-Imini area.

Crop	Yield (t/ha)
Maize	2.0
Cassava	10.0
Yam	10.0
Cowpea	0.2

The technologies were ranked according to importance taking into consideration the economic and agronomic criteria. Interventions where major input of research team is required in executing on-farm trials were classified as researcher managed and those that are simple and can be managed by farmers are considered farmers managed. For the first set of on-farm trials the following technologies were selected: 1) improved early maturing green maize, 2) improved maize and cassava for intercropping, 3) fertilizer use, 4) alley cropping, and 5) short maturing cowpeas and soybeans.

The selection of technologies to be tested in farmers fields was partly determined by socioeconomic considerations and constraints. One criterion was the ease by which a technology can be introduced. Easiest to introduce are technologies which increase output without requiring additional inputs or which make use of an underutilized resource. Technologies which demand more input of an already scarce factor are more difficult to introduce. The most difficult to introduce are those technologies which demand more of several scarce factors and may increase risk if inputs cannot be supplied in time. Technologies whose benefits accrue over a long time period also fall into this category.

Design of On-farm Trials

Selection of technologies was followed by design of on-farm trials. Priority was given to technologies that are simple and can be managed by farmers with minimum supervision by the team. This was done to demonstrate to farmers that the institute has good products to offer, to win their collaboration and to build up the capacity of the research team.

Trial 1. Early maturing and streak resistant maize (green)

This trial was designed to address the cash flow, the ‘hungry season’, soil fertility, maize streak virus disease, and erratic rainfall constraints. Treatments consisted of local maize streak and improved early maize (TZESR-W). Three fertilizer rates were applied using compound fertilizer (15-15-15) and calcium ammonium nitrate (CAN). The rates were 0-0-0, 45-45-45 and 90-45-45 in kg of NPK/ha. Farmers intercropped maize with local cassava using their crop densities and management practice. The fertilizer was applied by the research team while the rest of the operation was executed by farmers. The trial used a split plot design with farmers considered blocks or replications.

Trial 2. maize+cassava intercropping

This farmer managed trial was designed to address constraints on low yield potential of local varieties, low soil fertility, mosaic and streak disease on cassava and maize. Improved varieties used were TZSR-W an open pollinated, full season streak resistant maize, hybrid 8428-19,

and improved cassava (TMS 30572). Main treatments were 1) farmers practice (local maize+local cassava), 2) improved maize+local cassava, and 3) improved maized+improved cassava. Three fertilizer rates were super imposed on each treatment at the rate of 0-0-0, 45-45-45 and 90-45-45 in kg of NPK/ha. This trial followed a stepwise design (Mutsaers, et al, 1986) wherein the treatments represent a gradual change from farmers variety to complete replacement of his variety with improved varieties. The design used was split plot with farmers considered as blocks. Eight farmers used the open pollinated maize and 5 used hybrid maize.

Trial 3. Alley cropping with Leucaena

This new technology developed by IITA Farming Systems Program is designed to replace the traditional bush fallow farming system by planting hedgerows of fast growing leguminous trees and growing food crops in alleys formed by hedgerows. Pruning from leguminous trees are used as mulch and organic fertilizer. This technology provides long term solution to poor nutrient soils by regenerating and maintaining soil fertility under continuous cultivation (Kang, et al, 1984). Although there were previous on-farm trials with alley cropping (Ngambeki and Wilson, 1984; Atta-Krah, 1984) data are lacking on effect of hedgerows and pruning on yields of annual food crops in farmers traditional cropping system. Moreover, additional socioeconomic data are required for evaluating the adaptability of alley cropping by small scale farmers. A simple farmer managed trial comparing farmer’s traditional practice (without hedgerows) and alley cropping (farmer cropping practice + hedgerows) was established using Leucaena leucocephala. Farmers were instructed how to establish and maintain the hedgerows using IITA recommendations. They were free to select what crop to plant in the alleys, but majority planted maize and cassava. The trial was designed using a simple randomized complete block with two treatments.

Trial 4. Improved cowpea and soybean

Short maturing cowpea and soybean are potential crops during the second short season when rainfall is erratic. This trial was designed to investigate whether it was possible to reintroduce cowpea into the area using improved varieties and recommended insect control. Soybean is a new crop in the area and its introduction would determine its feasibility and viability as an alternative crop to cowpea. Its advantage over cowpea is the much lower insect infestation. The marketing problem needs is to be solved. Either cowpea or soybean would receive sufficient rainfall in the second season to mature and labor would not be a constraint, but above all this would fill a nutritional gap, the lack of protein. Presently, this gap is closed by imports of cowpea from northern Nigeria.

All trials with cowpea and soybean involved two treatments: sole and intercropping with maize of cassava. A 60-day cowpea variety IT84E-124 and a 75-day variety IT82D-716 were used for cowpea trial, whereas

a 105-day soybean variety TGx 536-03D was used for soybean trial. The trials were designed using randomized complete block with farmers serving as blocks or replications. All trials were established on fields of 0.1 ha.

Before the onset of the rainy season meetings with farmers were scheduled in the village. The trials were drawn on flip charts and their layout and objectives explained in detail. Farmers' and researchers' responsibilities were made clear. Farmers were assured that in case of a crop failure due to researchers' fault they would be compensated in kind. Choice of trials farmers wished to participate in was left to them. The response was so enthusiastic, that, unfortunately, some farmers had to be rejected.

Obviously, this method of selecting collaborators leads to a bias towards more progressive farmers. However, given the very limited resources, the team felt that obtaining reliable results should have priority over statistical requirements. Two teams were formed, one handling agronomic aspects the other collecting economic data. The agronomy team collects all information necessary to explain differences in yield using analysis of variance. It also advises on how to use newly introduced tools and equipment, how to determine optimal spraying times, etc. The socioeconomic team collects all the relevant data for whole budget analysis. These data are gathered for the whole field in which the trial is located. Differences in input requirements for the treatments are discussed with farmers. Their answers are compared with data which have been recorded on the research station. At present partial budgeting is used for economic evaluation. Price data for economic analysis are obtained from a market survey. Markets are held in the village every four days. Since large scale storage or processing facilities do not exist, prices show a distinct seasonal pattern which is more pronounced the more perishable the product.

ON-FARM TESTING AND EVALUATION

Technology 1. Improved Variety for Early Green Maize Harvest

In southwestern Nigeria there is a temporary food shortage during the period between the onset of the rainy season and harvest of the first crop. This period is known as the "hunger season". One reason for the popularity of maize in this area is because it is normally the first crop which can be harvested, thus, reducing the severity of the hunger season. Traditional late maturing local varieties are usually harvested green and consumed as roasted or boiled ears. Thus, green maize is the first fresh crop entering the market.

Six farmers conducted the trial, but only 4 completed the trial to harvest. Three farmers established the trial on newly cleared field of savanna/forest type which was under fallow for 10-12 years. Analysis of top soil (0-10 cm) from trial plots indicated a pH of 6.0-7.5, and organic carbon of more than one percent. Total N, available P and exchangeable K were on the sufficient range for a crop of maize. The sufficient levels of organic carbon and major nutrients are typical of newly cleared sandy Entisols common in the area.

Data in Table 2 show that total number of ears harvested was greater for improved maize that local maize at all level of fertilizer. This is a reflection of better plant stand achieved with improved maize under relatively similar farmers' plant population density. Final stand density at harvest was 25% more for improved maize than local maize. The percentage of marketable ears was higher with farmers' maize compared with improved maize, but since the plant stand was better with improve maize, the total number of marketable ears was higher with improved that farmers' maize. Marketable ears are the number of ears with sufficient size and quality to be marketed. The later maturing local variety had larger ears and higher percentage of marketable ears than the improved maize. Fertilizer application increased both the number and percentage of marketable ears, however, analysis of variance did not show significant results between varieties and among fertilizer levels. The sufficient levels of soil nutrients in newly cleared land may have negated the effect of fertilizer on green maize.

Profitability of green maize depends mainly on the number of marketable ears and market price. The improved maize produced larger number of marketable ears and was harvested two weeks earlier than the local variety. The difference in market price within the two-week period was dramatic (Fig. 5). Farmers received higher prices per ear very early in the season even though ears were small for improved maize. The marginal rate of return for the application of 45-45-45 kg NPK/ha is 234% for improved maize and 34% for the local maize. Improved maize clearly responded to improved management. Assuming that a rate of return of at least 40% is necessary for technology adoption, farmers; present practice is rational, but the application of fertilizer will be recommended for improved maize.

The demand for seed of improved early maturing maize increase such that in the following year 25 farmers participated in the trial.

Table 2. On-farm trials for green maize production. Agronomic results and a partial budget analysis for improved early (TZESR-W) and local late maturing maize varieties grown under three fertilizer levels*. Alabata, 1st season 1985.

Fertilizer (NPK)	0-0-0		45-45-45		90-45-45	
Variety	TZESR-W	Local	TZESR-W	Local	TZESR-W	Local
Total ears	31,500	24,300	33,200	25,700	31,500	22,900
Marketable ears	19,300	16,800	22,00	18,100	21,200	16,700
% Marketable	62	69	66	71	67	73
Value/ear	.08	.065	.08	.065	.08	.065
Gross benefit	1,550	1,090	1,760	1,180	1,690	1,080
Seed and fertilizer cost	50	20	115	85	140	110
Net benefit	1,500	1,070	1,645	1,093	1,550	970

*The partial budget includes only those costs which differ by treatment. Values are in Nigerian Naira/ha.

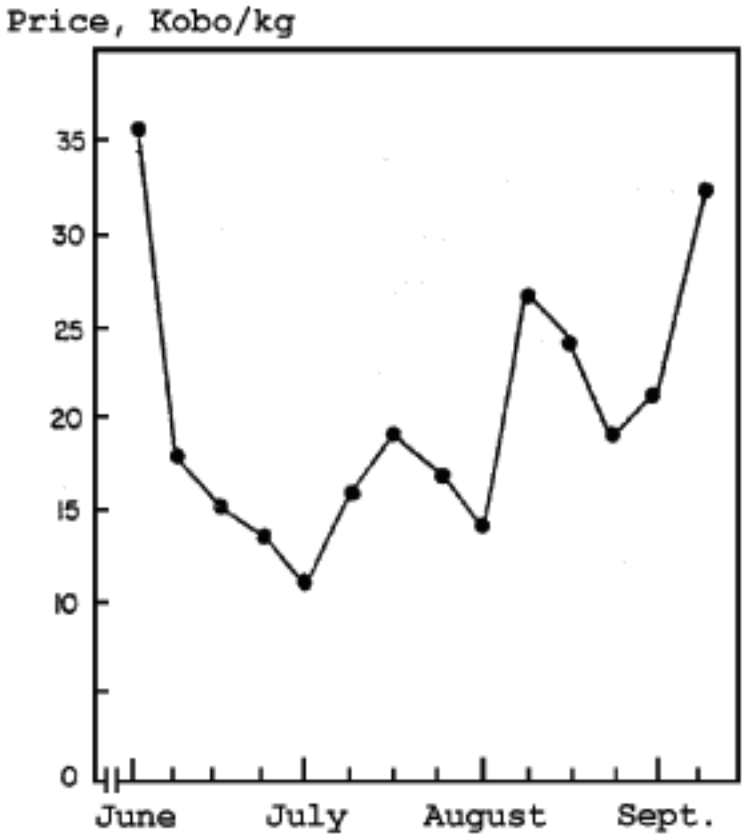

Fig. 5. Weekly green maize prices at Ljaiye market. 1985

Technology 2. Improved Maize and cassava Varieties for Intercropping

This technology testing covered the largest number of farmer cooperators. A total of 17 farmers participated in the trial, but only 13 farmers completed the trial. The objectives of this trial were 1) determine agronomic yield and economic returns of maize+cassava intercrop using farmers' and improved varieties and 2) determine yield response of maize intercropped with cassava to fertilizer application. Maize and cassava varieties and fertilizer rates are the independent variables.

Farmers planted maize and cassava using average plant density of about 30,000 plants/ha for maize and 10,000 plants/ha for cassava. Previous on-station study on plant spacing and density indicated that farmers plant density for maize and cassava was optimum for grain and tuber yield (Ezumah and Okigbo, 1980; Kang and Wilson, 1981) Increasing plant density above what farmers are using did not improve yields. Thus, the team did not consider varying plant density as an important intervention.

These trials were established by farmers on newly cleared plots and on fields cropped for 2 or 3 years. Soil analysis showed that most of the trial plots fall under newly cleared savanna/forest fields. Differences in pH, organic carbon, and total N were small between field types and cropping years, however, available P and exchangeable K were relatively on the high range on fields which are newly cleared.

The combined data for open pollinated maize presented in Table 3 show that the improved maize TZSR-W out yielded the local maize at all levels of fertilizer application. Even without fertilizer, improved maize produced 1 to 2 tons/ha more grain than local maize. With fertilizer the difference was 2 to 3 tons/ha. Hybrid maize yielded even better than local and open pollinated maize at all levels of fertilizer application (Table 4).

Separate analysis of variance for open pollinated and hybrid maize indicated significant yield difference between improved and local varieties. The effect of fertilizer was significant, however, variety x fertilizer interaction was not significant. To compare overall performance of local and improved maize under all range of management and environment, a modified stability analysis developed by Hildebrand, (1984) was performed. As shown in Fig. 6, without fertilizer the improved maize performed better that the local maize under all range of environment.

To make economic comparison between varieties and fertilizer levels simple, farmers' maize variety at zero fertilizer level was chosen as a reference point. Costs of this treatment were subtracted from the costs of all other treatments and only those costs which vary with treatment remain. Fifty percent of preplanting and weeding costs were allocated

Table 3. Maize grain yield intercropped with cassava at three levels of fertilizer NPK. On-farm trial, Alabata, 1st Season, 1985

Treatment	Variety	Fertilizer NPK (kg/ha) 0-0-0	45-45-45	90-45-45
		Yield, t/ha		
Farmers' practice	Local maize	1.90	3.00	3.42
Farmers' practice Improved maize Local cassava	TZSR-W	2.91	3.59	3.97
Farmers' practice Improved maize + Improved cassava	TZSR-W	2.90	4.01	4.44

Data average of 8 farmers

ANALYSIS OF VARIANCE

Source of Variation	M.S.	F Value	F Prob	LSD	C.V. (%)
Treatment (T)	6.43	6.08	$0.013^{.05}$	$0.64^{.05}$	17.7
Fertilizer (F)	11.85	27.37	<0.001	0.38	19.6
TXF	0.18	0.41	NS*	-	

*NS = Not Significant

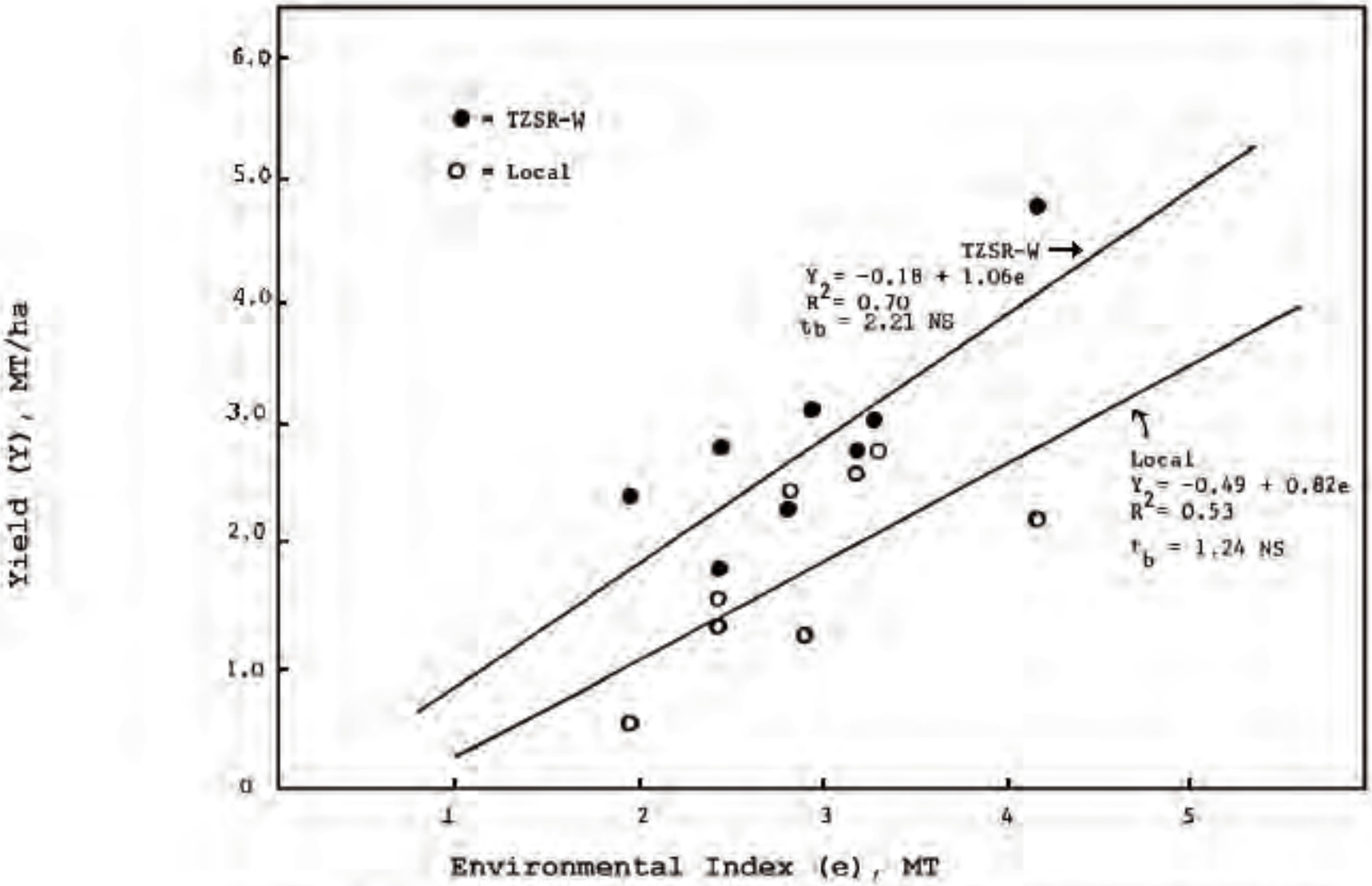

Fig. 6. Response of local and improved maize in environment without fertilizer, On-farm trial, Alabata, 1985.

to maize. The price of maize at harvest time was N250/ton. Assuming that a marginal rate of return (change in net returns over change in costs) of at least 40% is required to induce farmers to invest, a rate of 45 kg NPK/ha is recommended for the local variety while for the improved maize at least 90 kg NPK/ha can be applied profitably (Table 5). The higher rate is only profitable if calcium ammonium nitrate fertilizer is used. Most farmers are only familiar with compound fertilizer and would not apply more than 45 kg NPK/ha to maize.

Sensitivity analysis shows that no fertilizer should be recommended in case maize prices fall below N230/ton or if the price of compound fertilizer rises above N14/bag at a maize price of N250/ton at harvest. The marginal rate of return for planting improved maize instead of local variety is over 100 percent. Thus, the ranking of investment opportunities for the farmer is: first improve the variety then apply fertilizer. This ranking is likely to hold for the whole region. Thus, seed multiplication should have priority over fertilizer imports. This especially important as seed multiplication does not require foreign currency expenses while fertilizer imports do.

The use of hybrid maize was more profitable than open pollinated maize, however, hybrid maize requires seed purchases each year plus a functioning quality control and distribution system. Lack of cash and weak institutional infrastructure had been identified as important constraints. In contrast, farmers could be trained to grow improved open pollinated maize for seed and cash expenses are increased only once. It was felt that the hybrid maize is a technology of the future for small farmers.

Preliminary data on intercropped cassava indicated that better yield was obtained from improved cassava (TMS 30572) 12 months after planting (Table 6). There was no effect of fertilizer on cassava yield since fertilizer was applied only to maize. Farmers will harvest cassava again after 15 and 18 months when they expect prices will improve.

The maize+cassava trials demonstrated clearly that besides the agronomic aspects and food security this system offers two major economic advantages: 1) even at zero fertilizer level farmers recover all cash outlays and get paid for their own labor within one season, and 2) cassava with its low price variability is a hedge against the wide seasonal and annual fluctuations in maize prices.

Technology 3. Alley Cropping with Leucaena

The objectives of this test we to 1) establish alley cropping systems in farmers’ fields as an alternative to traditional bush fallow farming system, 2) determine agronomic an economic feasibility of alley cropping under farmers’ field conditions and 3) evaluate farmers’ response

Table 5. Comparison of Local Maize with TZSR-W for three fertilizer Levels on 8 farms in Alabata/Ijaiye, 1985

	Farmers' Maize			TZSR-W		
	Fertilizer Level (kg NPK/ha)					
	0-0-0	45-45-45	90-45-45	0-0-0	45-45-45	90-45-45
Grain yield (t/ha)	1.90	3.00	3.42	2.91	3.80	4.21
Net Returns (N/ha)	-10	60	72	112	172	203
Cost Varying with Treatment (N/ha)	0	151	197	104	243	303
Marginal Rate of Return	46	26		43	52	

Table 6. Tuber yield of cassava intercropped with maize 12 months after Planting. On-farm trial, Alabata, 1985-86.

Treatment	Fertilizer NPK in kg/ha			
	0-0-0	45-45-45	90-45-45	Mean
	Yield, t/ha			
Local cassava + Local maize +	8.33	12.05	14.82	11.73
Local cassava + Improved maize +	13.12	11.76	11.18	12.02
Improved cassava + Improved maize +	20.67	19.85	21.39	20.57

Data average of 9 farmers.

to alley cropping in terms of agronomic and economic parameters. The treatments consist of two plots, one representing farmer's traditional or normal cropping practice (no alley) and the other plot was planted with hedgerows of Leucaena, a fast growing nitrogen fixing tree. The hedgerows were planted at 4 m apart. Farmers planted maize and cassava before seeding of Leucaena. Because this technology is relatively new to the farmers in the area only 5 farmers succeeded in establishing the alleys after learning from researcher managed demonstration trial established near their plots.

Although the objective of alley cropping is to reduce fertilizer use, this benefit is only achieved after 3 or 5 years when the trees begin to produce considerable prunings. Thus, during the first year of establishment fertilizer may be required on maize for high yield especially if the soil is poor. In order not to disappoint the farmers, the maize was fertilized at the rate of 90-45-45 kg of NPK/ha. During the second year prunings will be used and fertilizer will be reduced to 45-45-45 kg NPK/ha. In the third and fourth years the fertilizer will be completely replaced by prunings. The idea is to wean the farmers from fertilizer use and at the same time enhance continuous cropping.

Since this was the initial year of the trial, the only observation recorded was on Leucaena establishment. In general, establishment was poor due to late planting by farmers. Instead of seeding two weeks after maize is planted, most farmers seeded Leucaena bout one month after maize was planted. This resulted in poor seedling stand. The 3 farmers who succeeded in establishing Leucaena achieved this only by reseeding. When Leucaena is seeded late seedlings are shaded by maize and growth is further reduced due to weed competition. However, once it is established and maize is harvested, growth is rapid and can attain a height of one meter in 3-4 months.

Some of the factors that determine acceptability and viability of alley cropping are 1) establishment of trees, 2) immediate benefits, 3) labor cost, and 4) land rights and tenure system (Francis, 1986; Ngambeki, 1984). Although alley cropping may be considered a composite technology (Mutsaers, 1985; Palada, 1986) its adoption can be accelerated through combined promotion and extension approach built in with on-farm research, a methodology used by ILCA (Atta-Krah, 1985).

The 10 alley cropping farmers will be monitored for 5 years to generate agronomic and socioeconomic data useful for further refinement of the technology. In addition, the OFR team established replicated researcher managed trials with controlled variables to determine both soil and crop improvement benefits.

Technology 4. Improved Early maturing Cowpea and Soybean

Second season rainfall in the derived savanna is short and erratic. This condition often results in crop failures especially with late season maize. In the past cowpea, a more drought tolerant crop, was extensively grown in the area. However, increasing insect pressure led to an almost complete disappearance of this crop. Cowpeas are now imported from northern Nigeria. Many farmers do not grow any second season crop.

Short maturing and/or drought tolerant crops such as cowpeas and soybeans could fill the gap and make better use of labor and provide a source of high protein food supply and cash income. Cowpea requires only 40 days of optimum soil moisture for optimum grain yield. Soybean is drought tolerant and attacked by relatively fewer insects. Preliminary on-farm trials in 1984 indicated that cowpea can be grown successfully provided insect pests were controlled by chemical sprayings. The profitability of cowpea production is determined by the degree of insect control and the cost of insecticides. Soybeans are a new crop in the area and farmers lack information on proper processing, utilization and marketing channels for sale.

During the meetings with farmers in two villages 8 farmers said they would like to try growing cowpeas if insect control was provided. Fourteen farmers expressed interest in growing soybean. Planting methods and cultural practices were explained and demonstrated for both crops. Special emphasis was put on processing and utilization was held in a portion of the crop for home consumption. For the first season IITA offered to purchase the rest if no other buyer could be found.

The objectives of cowpea trial were to 1) ensure the possibility and evaluate the potential of producing cowpea as a second season crop, 2) determine productivity and possibility of growing cowpea using improved practices, 3) determine the yield of cowpea intercropped with maize and cassava and 4) determine the relative economic returns of growing cowpea in sole and mixed cropping systems.

Three treatments were established on each farmer’s plot consisting of 1) sole cowpea, 2) cowpea+cassava and 3) farmer’s traditional practice of maize+cassava intercropping. Treatment 2 will determine the advantage of cowpea as an additional crop to farmer’s present practice. Plant spacing and population used in the trial followed the recommendation from IITA. All plots with cowpea received 3 or 4 sprayings to control aphids, thrips, pod bugs and borers. Two cowpea varieties were used for each treatment: IT84E-124 (60 days) and IT82D-716 (75 days). The 60-day cowpea received 3 sprayings while the 75-day cowpea received 4 sprayings. Sherpa Plus and Cymbush Super ED were used as chemical sprays.

Data in Table 7 show that yields obtained were less than 1.0 ton/ha for both varieties. IT84E-124 produced significantly higher yield than IT82D-716 under sole and intercrop systems. Yield obtained from sole crop was significantly higher than intercrop. Low yields can be attributed to several factors. Under farmer’s field conditionals, insect pressure was high. More thrips and pod bug damage were visually observed (no insect count was done) even with spraying. IT82D-716 suffered more insect damage than IT84E-124. Late planting also reduced the yield of cowpea. Two farmers who planted in August obtained the best yields. The level of management had also a greater influence on cowpea yield. Farmers who poorly managed their plots had lower yields than farmers who managed their plots very well.

Only 3 farmers harvested the intercropped maize. These were the farmers who planted early. Farmers who planted late were not able to harvest and yield as maize was seriously affected by drought around late October and early November. Therefore, maize yields cannot be reported here.

Soybean trials were conducted to 1) determine the possibility of growing soybean as an alternative crop to cowpea, 2) identify agronomic and socioeconomic constraints of growing soybeans based on farmers’ experience and 3) determine productivity and profitability of growing soybean using recommended practices.

Each farmer’s field was divided into three treatments, namely 1) sole soybean, 2) strip intercropping with cassava and 3) farmer’s practice (soybean intercropped with cassava using farmer’s planting pattern for cassava). All plots received 200 kg/ha of 15-15-15 fertilizer (30-30-30 kg/ha NPK). Plantings were done between July 1 and 15 using IITA early maturing soybean TGx 536-03D (105 days).

Table 8 shows the yield of soybean from 14 farmers. Average yield for monoculture (sole) was 858 kg/ha, whereas yields obtained from intercropping were 915 and 722 kg/ha, respectively. Yield from farmer’s practice was about 100-200 kg/ha lower than sole and strip intercropping. This difference was statistically significant (Table 8). The ranges in yields were high due to high variation in management practices and probably to differences in soil fertility. Weeds in some plots were a serious problem especially at the initial stage of establishment. Farmers were impressed by the excellent germination and stand of soybean. Most farmers weeded their plots only once during the entire growing season weeding. Other problems encountered by farmers were rodents and grass cutter damage. Very few insects were observed in soybean plots. The common insects were pod bugs and grasshoppers, but damage was not serious.

An economic analysis was done to compare the profitability of soybean and cowpea. At this time only the results from the sole crop trials could be evaluated. The 75-day cowpea IT82D-716 was not considered since

Table 7. Cowpea yield under two cropping patterns, On-farm trial, Alabata, 1985

Cropping Pattern	Variety	Yield, kg/ha Range	Mean
Sole	IT84E-124	0-786	400
	IT82D-716	32-526	213
Intercrop	IT84E-124	109-655	328
	IT82D-716	0-406	137
		LSD .05	CV %
	Cropping Pattern means	45.0	16.5
	Variety means	72.3	40.4

Table 8. Soybean yield under three cropping patterns. On-farm trial, Alabata, 1985. Variety TGx 536 – 030

Cropping Pattern	Yield, kg/ha Range	Mean
Sole	154 - 1466	858
Strip intercrop	152 - 1756	915
Farmer’s practice	77 - 1393	727

LSD .05 = 130 ; CV = 20.2%

Table 9. Total costs and returns for sole soybean and cowpea using variety IT84E-124. On-farm trial, Alabata, 1985.

Item	Soybean	Cowpea
Net yield (kg)	772	360
Gross returns at N1.20/1.70	926	612
Preharvest costs, N/ha		
Weeding	180	240
Chemicals + equipment	40	91
All other	306	315
Harvest costs, N/ha		
Labor	30	45
Other	72	28
Net returns, N/ha	298	-107

it did poorly. Table 9 highlights the results. Assuming a 10% yield loss between harvest and marketing about 2 weeks later, soybean yields more than double. The major differences in costs are for weeding and harvest labor and for chemicals. Soybean requires one complete and a light weeding while cowpea needs 2 weedings. Cowpeas are picked successively as they ripen, whereas soybeans are uprooted all at one time and then dried. Harvest and transport costs are N18 for cowpea and N13 for soybean per 100 kg bag. After fertilizer was applied to soybean, cowpea was sprayed 3 times. The differences in chemical costs are expected to widen as subsidies to important inputs are rapidly declining in Nigeria. Since credit is not usually available to farmers, this has serious implications for the cash flow. To enourage soybean production, IITA paid farmers N1.20/kg. a price of N0.80 is required to cover total production necessary to pay for all cash outlays. At the IITA offer price, 10 out of 14 farmers made a profit. The low yields incurred by 4 farmers could be attributed to late weeding and rat problems.

Cowpea fetch a good price in the market. However, only those 3 farmers who planted early, weeded timely and had excellent insect control made a profit. One farmer break even and the other 6 had negative net returns. This suggests that the degree of management has a significant influence on cowpea yield. This does not necessarily imply that cowpea production has no future in the area. But for a successful cowpea production a target group of farmers with high management skills and sufficient cash reserves needs to be identified. This first year of trials indicates that for most farmers, soybeans have higher potential than cowpeas.

The OFR team followed up on this preliminary assessment and interviewed farmers on soybean. The initial reaction to the new crop was very positive. Farmers compare soybean with cowpea and see the major advantages of soybean in the low weeding requirements and in the absence of insects. Most of them intend to expand soybean production in the following year. Farmers expressed concern about marketing. Great efforts are made to establish soybean both as a food and a cash crop. The utilization program will be explored in traditional dishes with soybean. Presently, the potential soybean processors in the Ibadan area are surveyed. Before the coming planting season a meeting between the most serious processors and farmers will be arranged to establish a secure market outlet.

SUMMARY AND CONCLUSION

IITA’s on-farm research is an integral part of the Farming Systems Program and plays an importance roll in technology transfer. The OFR activities are carried out in selected pilot research areas in Nigeria and in collaboration with national agricultural research centers, development and extension agencies. The research site in southwestern Nigeria

has complete a full cycle of on-farm research from exploratory surveying to on-farm testing and evaluation. In this site 2 target groups were identified. Farmers whose farmland is mostly in the savanna field “savanna farmers” and farmers whose fields are in the forest “forest farmers”. Both groups were found to grow the same crops, but slightly differ in their crop management and cultural practices. The principal arable crops grown in the area are maize, cassava, yam and vegetables. Maize and cassava intercropping is the most common cropping system. Among the major agronomic constraints identified were low inherent soil fertility, erratic late season rains and non-adapted crops and varieties leading to frequent crop failures in late season, build up of weeds over the years, grasshopper damage in cassava and maize streak virus disease. Shortage of labor for land preparation and weak input supply and extension services were cited as the common socioeconomic constraints in the area.

Agronomic on-farm trials were designed to address soil fertility constraints, erratic late season rains and low yielding crop varieties. The first set of on-farm trials involved use of improved maize and cassava varieties for intercropping, use of fertilizer, alley cropping and growing of short season crops like soybean and cowpea during the second season. Initial results of these trials suggest that short season improved maize harvested green, full season open pollinated and hybrid maize for grain, and soybean in the second season are promising technologies which can be adopted by farmers with low resource levels.

The on-farm testing program is now in its second year of operation and by the end of two years promising technologies will move into pilot scale extension program.

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Some Experiences and Achievements of Cropping Systems Research in Nepal

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Introduction

Multiple cropping or the growing of more than one crop in a piece of land in a year has been practised in developing and underdeveloped countries and it has offered several opportunities for the subsistence farmers to increase their farm productivity (Andrews and Kassam, 1973; Harwood and Price, 1976; Hildebrand, 1976; Harwood, 1973; Beets, 1982; Brady, 1982; Pendleton, 1982 and Gomez and Gomez 1983). The results of traditional agronomic research is often less suitable for small hold farmers because of ineffective extension methods, and due to farmers' unwillingness to accept new technology and inappropriate research stations' technology for the conditions of small hold farmers (Sah and Flinn, 1981; Gomez and Gomez, 1983 and Hildebrand, 1984). Cropping systems are defined as the cropping patterns used on a farm and their interactions with farm resources. The available technologies that determine the patterns' make up have a broad objective of increasing the efficiency of use of a given quality and a quantity of physical resources such as land, water, and and solar radiation in crop production (Zandstra, 1977). Carañgal (1977) mentioned that cropping systems are dependent on physical and socio-economic environments and are highly environments specific.

Research on Cropping Systems

The common cropping systems in a Nepalese subsistence farm area centuries old; they consist of sequential cropping, mixed cropping or relay cropping. However, no research results on improving cropping systems were reported in literature before the last decade. In 1977, the cropping systems program (CSP) of the Integrated Cereals Project (ICP) in collaboration with the Agronomy Division of the Department of Agriculture started research on cropping systems in the farmers' fields in six representative sites of Nepal (ICP-CSP 1977). Also, some other work on cropping systems from other researchers appeared in literature, but none of these works were carried out in farmers' fields. ICP has been publishing several cropping systems reports each year but most of them are not concise. So the attempt here

is to collect and update the cropping systems research activities covering a vide research which is of applied and problem-solving type. This review separates the cropping systems research work in Nepal into two categories: (1) Research work by ICP-CSP, and 2) Research done by entities other than ICP-CSP.

Research by ICP – CSP

Most of the research on cropping systems was done in farmers' fields as a component of the Asian Farming Systems Network (previously called the Asian cropping systems network) of International Rice Research Institute (IRRI) since 1977. The working group of this network developed a cropping system research methodology that is specifically suited for small farms and treats agricultural research as site-dependent (IRRI, 1975; Harwood 1975, IRRI, 1976; Zandstra, 1977; Zandstra and Carangal, 1977, Zandstra et al, 1981, and Zandstra, 1982). The broad objective of this network is to increase the cropping intensity in Asian rice farms and make more efficient the use of resources that are available or that can be made available to the farmer (Carangal, 1977). Hence, in Nepal, on-farm cropping systems research was started in the summer season of 1977 in Parsa (Central development region) and Pumdi Bhumdi (Western development region). Three other sites - Chauri Jahari (Far western development region), Lele (Central development region) and the Khandbari (Eastern development region) - were added in the winter season of 1977/1978. Ratnanagar (Central development region) was added in winter season of 1980/81 (Malla et al., 1982 and CSS, 1982). All the sites were described and characterized by the methodologies of IRRI in 1977 (ICP-CSP, 1977; Lohani, 1979 and Zandstra et al., 1981). Several alternative cropping patterns, including minor crops especially grain legumes, were tested in all sites. Fodder crops were also included in Pumdi Bhumdi because farmers showed interest in keeping the livestock but grasses and fodder were lacking (Mathema, 1982 and M.V.D. Veen, 1982). The same scenario was true with Khandbari (Mathema, 1982). A summary of the physical description of the six cropping systems sites of Nepal is presented in Table 1. Figure 1 shows the three major ecological zones and locations of cropping systems sites in Nepal. Figures 2 to 7 present the monthly rainfall and temperature means from 1978 to 1984 for six cropping systems sites of Nepal. Cropping systems research activities in Nepal consisted of:

1. Varietal and cropping patterns testing in cropping systems sites.
2. Pre-production Verification Trials
3. Pilot Production and production programs

The fertilizer responses and other component technologies were not included in this paper.

1. Varietal and cropping patterns testing in cropping systems sites:

a. PUMDI BHUMDI: Rice-wheat-maize (total pattern yield of 9.36 t/ha) and rice-fallow-maize (total pattern yield of 6.54 t/ha) patterns had the potential of increasing the cropping intensity and total production in rainfed lowlands where rice-wheat, rice-mustard and rice-fallow were the existing farmers' patterns. Similarly, maize/finger millet-wheat (total pattern yield of 6.56 t/ha) and maize/finger millet-mustard (total pattern yield of 6.49 t/ha) were found to be better than the existing farmers' patterns of maize-wheat and maize-finger millet in rainfed uplands (ICP, 1982, CSS 1982, CSS 1983 and CSS 1984).

Rice varieties Taichung 176 and K-39, maize variety Arun and wheat varieties RR 21 and Triveni were found to be promising in all land types (CSS, 1982; CSS, 1983 and CSS, 1984). Other crops that were tested include potato, *Sesbania* sp. and oat. The increase of yields of rice due to *Sesbania* sp. was significant (CSS, 1984). Performance of grain legumes other than broad beans have not been reported in literature, hence there is a need for research in grain legume breeding and testing in the hills. Since grain legumes, especially cowpea, have several advantages including a significant quantity of biomass as fodder for livestock (Timsina, 1984 and Timsina, 1985), research is needed on this pulse in the hills.

Pumdi Bhumdi is the only site where research has already been started on a farming systems perspective rather than simply a cropping systems perspective (Sayre et al., 1984). The socioeconomic research and the initial results of farmer monitoring for farming systems research helped in developing a better understanding about farming systems in the mid-hill areas with a special focus on the crop and livestock activities in the farms (Delobel, 1985 and Delobel et al., 1985). The first year of livestock feeding trials, with oats as a supplement to the dry feed, indicated that oats could be an economical, viable option in wheat cultivation at Pumdi Bhumdi (Singh and Gautam, 1985 and Singh and Joshi, 1985). Some other reports also provide useful information on outcomes of early phase of farming systems research at Pumdi Bhumdi, Nepal (Delobel, 1985; Shrestra, 1985a; Shrestha, 1985b; K.C. 1985).

b. CHAURI JAHARI: Earlier research indicated that mungbean or rice could be planted after wheat or before rice in existing farmers' rice-wheat pattern of irrigated lowlands. The existing

farmers' pattern was found to be superior (9.38 t/ha) to rice-wheat-rice and rice-wheat-mungbean (8.19 and 7.44 t/ha respectively) patterns since some difficulties were encountered in the latter patterns (ICP-CSP, 1977 and ICP, 1982). For uplands with irrigation in winter, upland rice+maize-wheat-fallow (7.68 t/ha) and upland rice+maize-wheat+mustard-fallow (7.63 t/ha) were more profitable than the farmers' patterns of upland rice+maize-fallow and fingermillet-wheat (ICP-CSP, 1977, CSS, 1982, CSS 1983, and CSS 1984). However, fingermillet-wheat pattern could be changed into maize-fingermillet-wheat pattern. One more crop could be included in spring in all the patterns so as to increase cropping intensity and total pattern yield.

Bindeswari rice performed well in upland rice+maize-wheat-fallow and upland rice+maize-wheat+mustard-fallow pattern and gradually farmers adopted this Bindeswari rice variety (CSS 1983 and CSS 1984). In irrigated lowlands, sabitri rice performed well in rice-wheat-fallow and rice-wheat+mustard-fallow patterns. K- 39 was excellent in a rice-wheat-rice pattern (CSS, 1983 and CSS, 1984). Arun maize performed best in upland rice+maize-fallow and upland rice+maize-wheat+mustard-fallow patterns (CSS, 1982; CSS 1983 and CSS, 1984). NL 292 and RR21 wheat varieties performed best in upland-and lowland-based patterns respectively (CSS, 1983). RR21 performed better than Triveni in rice wheat+mustard-fallow but Triveni did better than RR21 in rice-wheat+mustard-mungbean pattern where mungbean was taken as a green manure crop (CSS 1984). More research is necessary on grain and fodder legume to be grown in spring so as to increase the cropping intensity and protein and fodder requirements of humans and livestock.

c. KHANDBARI: Maize-maize-fallow and rice-wheat-maize were found to be promising (total pattern yield of 5.56 and 9.57 t/ha under rainfed uplands and irrigated lowlands respectively) where initially farmers used to follow rice—fallow and rice-wheat sesamum-fallow patterns in uplands. However, the pattern rice-wheat- mungbean that involved a legume gave a total yield of 6.67 t/ha showing the potential of mungbean in increasing total yield (CSS, 1983).

K-39 performed well in all patterns of rainfed lowlands. Farmers were keenly interested in replacing the local variety with K-39 in the first crop of rice-rice-wheat and rice-rice fallow patterns (CSS, 1983, CSS 1984 and CSS 1985). Khumal yellow was rapidly adopted by farmers over Rampur composite for the first crop of maize-maize-fallow pattern. For the second crop of this pattern, Arun-1 showed excellent performance. Farmers also liked it because of its white grain (CSS, 1983; CSS, 1984 and CSS, 1985). Triveni performed better than UP 262 in rice-wheat-maize pattern of irrigated lowlands and RR-21 did better than Triveni in rice-wheat-fallow pattern of rainfed lowlands (CSS, 1984). CES-55 variety of mungbean was found to be promising in rainfed lowlands. Sesbania sp. significantly

increased the yield of the succeeding K-39 rice (CSS, 1985). Although, the contribution of Sesbania sp. in terms of nitrogen yields has been reported elsewhere (Bronson, 1983, Rajbhandary,1984 and Furoc, et al., 1986), further research is necessary to confirm such contributions under the hill conditions of Nepal. As in Pumdi Bhumdi and Chauri jahari, research on different grain and fodder legumes should be continued at this site (Mathema, 1982).

d. LELE: After the introduction of the improved practices in the predominant farmers' patterns of rice-wheat, maize+ soybean-mustard, and maize/fingermillet, the first pattern produced a total pattern yield of 8.33 t/ha in irrigated lowlands and the second pattern 6.23 t/ha in rainfed uplands. Rice varieties Kanchan, K-39 and NR 10041-66-3-1 performed better than Taichung 176; and Chainung 242, and Triveni wheat did better than other wheat varieties in rice-wheat pattern (CSS, 1983 and CSS, 1985).

e. RATNANAGAR: Before the start of the cropping systems program, the farmers predominant patterns were rice-fallow and rice-wheat in lowlands and maize-mustard in uplands. With the development and testing of the alternative cropping patterns, maize-maize/wheat (8.2 t/ha) and upland rice+maize-mustard (4.27 t/ha) appeared promising under uplands. Similarly, rice-fallow-maize (8.06 t/ha), rice-fallow-Sesbania sp. (3.18 t/ha) and rice-wheat-fallow (8.63 t/ha) performed well in rainfed areas. The patterns such as rice-wheat-maize (10.07 t/ha), rice-potato-maize (16.36 t/ha), rice-wheat-Sesbania sp. (8.91 t/ha) and rice-wheat-mungbean (8.68 t/ha) gave promising results in irrigated areas (ICP 1982, CSS 1982, CSS 1983 and CSS 1984).

Laxmi variety of rice appeared to be best in triple cropped irrigated lowlands but Janaki variety performed better in rice-mustard-fallow and rice-wheat-fallow patterns. Bindeswari rice was also found to be promising in these patterns (CSS, 1983, CSS, 1984 and CSS, 1985). Arun variety of maize appeared to do better in maize-maize/wheat; Rampur composite did better in rice-fallow-maize and rice-mustard-maize patterns. In irrigated lowlands, Lumbini variety of wheat performed better in rice-wheat-mungbean and rice-wheat-maize patterns but Vinayak variety did better in rice-wheat-Sesbania sp. and rice-wheat-fallow patterns. In rainfed lowlands, RR 21 wheat was found to be better in rice-wheat-fallow patterns, and Pusa Baisakhi variety of mungbean did better than PS7 in rice-wheat-mungbean pattern (CSS, 1982, CSS, 1983 and CSS, 1984).

f. PARSA:

i) SUKCHAINA (RAINFED): Before the start of the cropping systems program, rice-wheat-fallow, rice-maize, rice-barley/lentil, and rice-fallow were the predominant patterns in Sukchaina. After the introduction of improved practices, rice-wheat-fallow pattern still remained popular (ICP 1982 and CSS 1984). However, rice-chickpea-fallow gave the highest total annual yield and income (total pattern yield of 4.57 t/ha with an annual income of $1000.00/ha) according to Singh and Sayre (1985). Rice-mixed crops-fallow (with lentil, mustard and linseed being the major component crops of mixed cropping),rice-mustard-maize, and rice chickpea+mustard-fallow became the other predominant patterns (CSS 1983 and CSS 1984). Rice-chickpea+ mustard-fallow pattern has been a major research contribution in sukchaina and because of the outstanding performance of this pattern, there has been a rapid adoption of crop production technologies through the promotion done by cropping systems activities (CSS, 1983 and Singh and Sayre, 1985).

Rice varieties Bindeswari, Malika, Laxmi and IR 8423 performed very well in rice-chickpea-fallow and rice-wheat-fallow patterns but Saryu-49 variety was found to be better in rice-mustard-maize pattern (CSS 1985). UP 262, RR21 and Triveni variety of wheat performed well but not consistently in different years, hence exact recommendations cannot be made. Further testing is necessary (CSS, 1982, CSS 1983 and CSS 1984). Best varieties of chickpea were identified, namely: Go 232, pant 113, Go 332-10 and Go 266-12 yielding up to 1.71 t/ha (CSS, 1983 and CSS 1984). In fact, Go 332 performed best and helped the farmers of Sukchaina increase their economic status from rice-chickpea-fallow pattern (CSS 1983 and Singh and Sayre, 1985).

ii) BAHUWARI (TUBEWELL - IRRIGATED)

Before the start of the cropping systems program, the farmers' predominant patterns were rice-fallow, rice-wheat fallow, and rice-maize-fallow. After tests with several cropping patterns for over five years the patterns rice-rice-wheat (9.68 t/ha), rice-mustard-maize (8.08 t/ha), rice-wheat-*Sesbania* sp. (8.29 t/ha), rice-wheat-mungbean (7.88 t/ha), rice-maize mungbean (11.03 t/ha), rice-maize-maize (13.27 t/ha), rice potato-maize (13.99 t/ha) and rice-rice/lentils (6.68 t/ha) showed better potential (CSS, 1982, CSS 1983, CSS 1984 and CSS 1985) in tubewell irrigated areas of Bahuwari.

Although short duration rice varieties like Chandina,Durga, Laxmi, Bindeswari and Janaki were found to be better for most of the tripple cropping patterns, Masuli and Malika respectively

were found to be better in summer and spring conditions in rice-rice-wheat pattern (CSS 1982, CSS, 1983 and CSS, 1984). Arun maize was found to be better for the second crop; and Rampur composite and Rampur yellow maize were better for the third crop in rice-maize-maize and rice-maize-mungbean patterns. Rampur composite was also found to be better in rice-mustard-maize pattern (CSS, 1983, CSS 1984 and CSS 1985). UP 262 and Vinayak varieties of wheat were found to be better in rice-wheat-mungbean and rice-wheat-rice patterns but Lumbini and UP 262 performed ell in rice-wheat-Sesbania sp. pattern (CSS, 1983 and CSS, 984). PS 7 variety of mungbean performed better in rice-wheat-mungbean and rice-maize-mungbean patterns than Pusa Baisakhi farmers preferred the former variety over others because of its older grain and synchronous flowering (CSS, 1984).

The summary of the achievements in increasing the cropping intensity and in the adoption of improved crop species and varieties for six cropping systems sites of Nepal are presented n Tables 2 and 3. Tables 4 to 10 present the comparisons of the results of pattern trials under different land types in various cropping systems sites for 1982-1984 (Bhattarai, 1985). The tables clearly indicate that in all the sites, improved practices ere superior to farmers' practices. The superiority of improved practices over that of the farmer could be one of the reasons for he adoption of the former practices.

2. Pre-production Verification Trials (PPVTs):

Cropping systems programs' PPVTs were started in Nepal in 1981. The strategies and guidelines for implementation of PPVTs ere described by CSS (1982), CSS (1984), Lipinski and Rizal 1984) and Sayre et al.(1984). PPVTs were carried out in different parts of the country for different patterns (Malla et l., 1983). They have been proven to be successful, especially or low to mid-hill rice-wheat and maize-wheat cropping patterns Lipinski and Rizal, 1984). A survey of the farmers by ICP-CSP socio-economists and agronomists group in some districts of western hills indicated that PPVTs are useful, effective and are an appropriate tool in significantly spreading the CSP-recommended technology for the undeveloped hill districts of Nepal (Lipinski et al, 1984).

3. Pilot Production and Production Programs:

CSS (1981) endorsed the cropping systems-based production programs to increase the total farm productivity; it also mentioned the minimum requirements for a successful production program. Strategies and management supports needed for launching production programs in Nepal were mentioned by Malla et al 1983), Bolo (1983), Bolo (1984), Bolo and Malla (1984), Sayre et

al (1984) and Malla et al (1985). Pilot production programs were started in 1981/82 in five cropping systems sites for different cropping patterns and under different land types (Malla et al., 1983). A total of 642.5 ha of wheat were covered by the program during the winter 1982-1983; 1274 ha of rice and 35 ha of maize during summer of 1983; and 12 ha pf Sesbania sp. and 2.5 ha of mungbean during spring of 1983 in six cropping system sites of Nepal (Bolo, 1983 and CSS, 1983). Production programs were launched in Bara, Parsa, Chitwan, Sarlahi and Rautahat in 13665 ha for wheat and maize in 1982-1983, in 16,522 ha for wheat in 1983-1984, and estimated to be 50,000 ha for different crops in 1985 (Bolo and Malla, 1984, Sarkar and Chitrakar, 1984 and ICP, 1984). Production programs demonstrated that high yields could indeed be achieved; that farmers are ready to change and accept new farming practices to increase their yield; and that the system can effectively support a production program when properly managed (Bolo, 1984).

Research other than by ICP-CSP:

No suitable research methodologies for on-farm research have been reported. However, rice-wheat-fallow, rice-rice-wheat, maize-mustard-fallow and potato+maize-fallow patterns were tested for some years. RR 21 and UP 262 wheat varieties were found to be promising in the first and the second patterns respectively in eastern hills of Nepal (PAC, 1984). Some work on intercropping of maize and grain legumes have been reported in literature. Reports demonstrated that among the grain legumes intercropped with maize, cowpea was found to be better in some years (Pathic and Malla, 1980) whereas in other years, soybean was better (Pathic et al., 1982). Other intercropping work of maize and soybean were reported by Lohani and Jaiswal (1977), Bharati et al. (1977), Bharati et al. (1979), Jaiswal and Bharati (1979), Bharati and Neupane (1980), Pathic et al. (1981), PAC (1982), Sen and Sthapit (1982) and Neupane (1983). In every case, intercropping was found to be superior to monoculture; such superiority was due to the less incidence of pest in soybean intercropped with maize (K.C. and Pant, 1983 and K.C., 1985). Intercropping of maize with fingermillet (Sen and Sthapit, 1981) and with peanut (Lohani and Jaiswal, 1977) and of wheat with pea (PAC, 1982) also showed intercropping to be better than sole cropping. In a multiple cropping trial of maize, soybean, peanut, and wheat, Jaiswal and Bharati (1979) reported that soybean relayed with summer maize, gave the highest yield in the different patterns tested.

Conclusions

The review shows that the cropping systems research in Nepal has gained some achievements especially due to the cropping systems program of the Integrated Cereals Project. Even though, the cropping systems research started less than a decade ago, it was able to develop suitable technologies in the farmers' fields. The technologies were then disseminated through pre-production verification trials and production programs. The production programs proved that the food production could be increased in hills and terais of Nepal by following a cropping systems approach. Farming systems research in only one site (Pumdi Bhumdi) for only one year indicated that the farming systems research can really be helpful in improving the economic status of the hill farmers of Nepal.

Suggestions and Future Research Needs

1. In Nepal, where resource - poor farmers are dominant and subsistence farming systems is prevalent, a holistic research approach should be followed. The present cropping systems program has focused only on the crop component (except for Pumdi Bhumdi site). The livestock component has been ignored in research. Hence, the livestock component should be added so as to have a holistic approach in research. As suggested by Chambers and Ghildyal (1984), farmer-first-and-last model is better for resource-poor farmers than the normal transfer of technology model.

2. More farming systems sites should be so selected as to represent different parts and agro-climatic conditions of the country such as higher hills, mid-hills, lower hills, inner terai and terai.

3. More alternative cropping patterns should be tested for specific land type and agro climatic conditions. The most economically and socially acceptable cropping patterns that benefit the resource-poor farmers in specific land and agro climatic situations should be identified.

4. Since, the success of cropping/farming systems research depends upon the active participation of the participating farmers, it is suggested that more and more farmers as "farmer cooperator" be included in research. Hence, at the time of the selection of the farmer cooperator, the farmers with different land types should be asked and encouraged to participate in the

program. Since, small farmers have usually less risk-bearing capacity during testing phase because of the size of their farm being small, some sort of incentives or remunerations should be provided in case the enterprise fails due to an aberrant or unfavorable weather.

5. Grain and fodder legumes should get high priority in research as they have a great potential in maintaining soil fertility and natural resources, in meeting the quality fodder requirements of livestock and in eliminating the malnutrition problems of the increasing human population. Similarly, research on low-cost input .pa crop species such as fingermillet, buckwheat, barley, and oat also deserve special priority for the condition of resource-poor farmers especially in the hills.

6. Since the cropping/farming systems research is carried out by an inter-or multi-disciplinary team composed of biological and social scientists, its success depends upon the close coordination and cooperation among the members of the team. The success of cropping/farming systems research, thus depends upon the strong commitment, sincerity, and hard work by the researchers and the farmers. As in the past, the researchers should be dedicated to the farmer-oriented research.

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Acknowledgement

The author is very grateful to Dr. C.N. Hittle, Supervisor of the Integrated Cereals Project, Nepal for providing different cropping systems reports published by the Integrated Cereals Project.

Table 1. Description of cropping systems sites in Nepal.

	Sites						
	Pumdi Bhumdi	Parsa (irrigated)	Parsa (rainfed)	Chauri Jahari	Lele	Khandbari	Ratnanagar
Elevation (m.a.s.l.)	750-1270	150	150	700	1300-1500	460-1100	350
Rainfall (mm)	4000	1500	1500	1100	1800	1200	1800
Rainfall distribution							
Wet months*	6	4	4	3	4	2	4
Dry months	5	8	8	8	6	6	8
Major soil	Inceptisol	Inceptisol	Inceptisol	Inceptisol	Inceptisol	Inceptisol & ultisol	Inceptisol
Major land types	1. Lowland rainfed	1. Lowland irrigated	1. Lowland rainfed	1. Lowland rainfed	1. Lowland rainfed	1. Lowland rainfed	1. Lowland rainfed
	2. Upland rainfed			2. Upland rainfed in the summer &irrigated winter	2. Lowland rainfed	2. Lowland rainfed	2. Lowland rainfed
				3. Lowland irrigated	3. Lowland irrigated	3. Lowland irrigated	3. Lowland irrigated
Farm size (ha/farm)	0.87	0.85	0.85	0.91	0.63	1.1	0.68

*Wet months refer to those months receiving more than 200mm rainfall and dry months receiving less than 100 mm rainfall.

Table 2. summary of achievements in increasing cropping intensity in six cropping systems sites of Nepal (as of December, 1985)

Sites	Cropping Patterns Adopted*	
	Before the start of the program	Now
Pumdi Bhumdi		
A. Rainfed lowlands		
	1. Rice-Fallow	1. Rice-Fallow-Maize
	2. Rice-Wheat	2. Rice-Wheat-Maize
	3. Rice-Mustard	
B. Rainfed uplands		
	1. Maize-Wheat	1. Maize/Fingermillet-Wheat
	2. Maize-Fingermillet	2. Maize/Fingermillet-Mustard
Chauri Jahari		
A. Irrigated lowlands		
	1. Rice-wheat	1. Rice-Wheat-Rice
		2. Rice-Wheat-Mustard
		3. Rice Wheat+Mustard-Rice
B. Rainfed/irrigated uplands		
	1. Upland rice+Maize-Fallow	1. Upland Rice+Maize-Wheat-Fallow
	2. Fingermillet-Wheat	2. Upland Rice+Maize-Wheat+Mustard-Fallow
		3. Maize/Fingermillet-Wheat
Khandbari		
A. Irrigated lowlands		
	1. Rice-Fallow	1. Rice-wheat-Fallow
	2. Rice-Wheat	2. Maize-Maize-Fallow
		3. Rice-Wheat-Mungbean
B. Rainfed upland		
	1. Maize-Fingermillet	1. Rice-Wheat-Fallow
	2. Maize-Ginger	2. Maize-Maize-Fallow
	3. Sesamum-Fallow	

*In any cropping patter, the first, the second, and the third crop are summer, winter, and spring crops, respectively.

Table 2. continued

Sites	Cropping Patterns Adopted*	
	Before the start of the program	Now
	Lele	
A. Irrigated lowlands		
	1. Rice-Wheat (without improved practices)**	1. Rice-Wheat (with improved practices)
B. Rainfed uplands		
	1. Maize+soybean-mustard (without improved practices)	1. Maize+soybean-mustard (without improved practices)
	2. Maize/Fingermillet-Fallow (without improved practices)	2. Maize/Fingermillet-Fallow (with improved practices)
	Ratnanagar	
A. Rainfed lowlands		
	1. Rice-Fallow	1. Rice-Fallow-Maize
	2. Rice-Wheat	2. Rice-Fallow-*Sesbania* sp.
		3. Rice-Wheat-Fallow
B. Irrigated lowlands		
	1. Rice-Fallow	1. Rice-Wheat-Maize
	2. Rice-Wheat	2. Rice-Potato-Maize
		3. Rice-Wheat-*Sesbania* sp.
		4. Rice-Wheat-Mungbean
C. Rainfed uplands		
	1. Maize-Mustard	1. Maize-Maize/Wheat
		2. Upland Rice+Maize-Mustard

*Without improved practices' means the use of local varieties and without the use of fertilizer and other pest control measures, whereas 'with improved practices' means the use of improved varieties and some use of fertilizer and other pest control measures.

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Table 2. continued

Sites	Cropping Patterns Adopted*	
	Before the start of the program	Now
	Parsa	
A. Sukchaina (rainfed)		
	1. Rice-fallow	1. Rice-Wheat-Fallow
	2. Rice-Wheat	2. Rice-Chickpea-Fallow
	3. Rice-Maize	3. Rice-Mixed crops-Fallow
	4. Rice-Barley/Lentil	4. Rice-Mustard-Fallow
		5. Rice-Mustard-Maize
		6. Rice-Chickpea+Mustard-Fallow
B. Bahuwari (Tubewell-irrigated)		
	1. Rice-Fallow	1. Rice-Rice-Wheat
	2. Rice-Wheat	2. Rice-Mustard-maize
	3. Rice-Maize	3. Rice-Wheat-*Sesbania* sp.
		4. Rice-Wheat-Mungbean
		5. Rice-Maize-Mungbean
		6. Rice-Maize-Maize
		7. Rice-Potato-Maize
		8. Rice-Rice/Lentils

Table 3. Summary of the achievements in the adoption of improved crop species and varieties in six cropping systems sites of Nepal (as of December, 1985).

Sites	Crop Varieties Adopted
I. Pumdi Bhumdi	
a. Rice:	Taichung 176, K-39
b. Maize:	Arun
c. Wheat:	RR21, Triveni
d. Potato:	
e. Cowpea (as grains and fodders)	
f. Oats (as fodder)	
g. *Sesbania* sp. (as green manure)	
II. Chauri Jahari	
a. Rice:	Bindeshwari, Sabitri, K-39
b. Maize:	Arun
c. Wheat:	NL292, RR21, Triveni
d. Mungbean (as green manure)	
III. Khandbari	
a. Rice:	K-39
b. Maize:	Khumal yellow, Arun-1
c. Mungbean (as green manure)	CES-55
d. Wheat:	Triveni, RR21
IV. Lele	
a. Rice:	Kanchan, K-39, NR10041-66-3-1
b. Wheat:	Triveni
V. Ratnanagar	
a. Rice:	Laxmi, Janaki, Bindeshwari
b. Maize:	Arun, Rampur Composite
c. Wheat:	Lumbini, Vinayak, RR21
d. Mungbean (as grain and as green manure)	Pusa Baiaskhi
e. *Sesbania* sp. (as green manure)	
f. Cowpea (as green pods and grains)	
VI. Parsa	
A. Sukchaina (rainfed)	
a. Rice	Bindeshwari, Mallika, Laxmi, IR8423, Saryu 49
b. Wheat	UP262, RR21, Triveni
c. Chickpea:	GO332, Pant 113, GO266-12, GO-332-10
B. Bahuwari (irrigated)	
a. Rice:	Chandina, Durga, Laxmi, Bindeshwari, Janaki, Masuli, Malika
b. Maize:	Arun, Rampur, Composite, Rampur yellow
c. Wheat:	UP262, Vinayak, Lumbini
d. Mungbean (as grain)	PS 7
e. *Sesbania* sp. (as green manure)	

Table 4. Improved vs. farmer cropping patterns: rainfed lowland, Pumdi Bhumdi, Kaski, Nepal (avg. 1982-84).

Pattern	Crop Yield (t/ha)				Returns Over Variable Costs	
	Summer	Winter	Spring	Total	$/ha	Gain (%)[1]
Farmer						
Rice-wheat-maize	2.6	1.6	2.0	6.2	616.7	-
Rice-fallow-maize	2.4	-	2.3	4.6	472.2	-
Rice-fallow-fallow	2.4	-	-	2.4	338.9	-
Improved						
Rice-wheat-maize	2.7	1.7	2.7	9.2	844.4	37
Rice-fallow-maize	4.1	-	2.4	6.5	627.8	33
Rice-fallow-fallow	3.3	-	-	3.3	472.2	41

[1] Each improved cropping pattern is compared with the same farmer pattern practice

Table 5. Improved vs. farming cropping patterns: irrigated lowland. Chauri Jahari, Rukum, Nepal (avg. 1982-84).

Pattern	Crop Yield (t/ha)				Returns over variable costs[2]	
	Summer	Winter[1]	Spring	Total	$/ha	Gain (%)[3]
Farmer						
Rice-wheat+ mustard-fallow	3.9	2.2	-	6.1	1105.6	0
Improved						
Rice-wheat+ mustard-fallow	4.9	3.2	-	8.1	1583.3	43
Rice-wheat+ mustard-rice	2.3	3.2	3.8	9.3	1511.1	37

[1]Combined yields of wheat and mustard.

[2]Labor and power costs not included in variable estimates.

[3]Compared with farmer pattern.

Table 6. Improved vs. farmer cropping patterns: partially irrigated lowland, Khandbari, Sankhuwasabha, Nepal (avg. 1982-84).

Pattern	Crop Yield (t/ha)				Returns over variable costs	
	Summer	Winter	Spring	Total	$/ha	Gain (%)[1]
Farmer						
Rice-fallow-maize	2.4	-	1.9	4.3	544.4	-
Improved						
Rice-wheat-maize	3.9	2.8	3.0	9.7	1255.6	131
Rice-wheat-mungbean	3.4	2.4	0.7	6.6	822.2	52

[1]Compared with farmer pattern

Table 7. Improved vs. farmer cropping patterns: irrigated lowland, Bahuwari Tubewell Parsa, Nepal (avg. 1982-84).

Pattern	Crop Yield (t/ha)				Returns Over Variable Costs	
	Summer	Winter	Spring	Total	$/ha	Gain (%)[1]
Farmer						
Rice-wheat-rice	1.7	2.2	3.5	7.4	572.2	-
Rice-wheat-fallow	3.4	2.4	-	5.9	644.4	-
Improved						
Rice-mustard-maize	4.0	0.9	2.6	7.5	761.1	18
Rice-maize-maize	4.7	5.6	3.0	13.3	1350.0	109
Rice-maize-mungbean	3.6	5.1	0.3	9.0	733.3	14
Rice-wheat-*Sesbania*[2]	4.5	3.3	-	7.8	722.2	12
Rice-wheat-fallow	4.0	3.3	-	7.3	688.9	6
Rice-wheat-rice	2.6	2.7	4.3	9.6	77.8	36

[1]The improved version of rice-wheat-rice is compared with the pattern under farmer practice. All other improved patterns are compared against the farmer practice of rice-wheat-fallow.

[2]Green manure crop.

Table 8. Improved vs. farming cropping patterns: rainfed lowland in limited production potential Sukchaina, Parsa, Nepal (avg. 1982-84).

Pattern	Crop Yield (t/ha)			Returns Over Variable Costs	
	Summer	Winter	Total	$/ha	Gain (%)[1]
Farmer					
Rice-wheat-fallow	2.2	1.3	3.6	238.9	-
Improved					
Rice-wheat-fallow	2.7	1.8	4.5	300.0	27
Rice-mustard-fallow	2.8	0.4	3.2	277.8	15
Rice-lentil-fallow	2.4	0.6	3.0	194.4	-19
Rice-chickpea-fallow	3.3	1.2	4.6	550.0	131

[1]Compared with farmer patterns.

Table 9. Improved vs. farmer cropping patterns: irrigated lowland Ratnanagar, Nepal (avg. 1982-84).

Pattern	Crop Yield (t/ha)				Returns Over Variable Costs	
	Summer	Winter	Spring	Total	$/ha	Gain (%)[1]
Farmer						
Rice-wheat-fallow	3.4	1.9	-	5.3	433.3	-
Improved						
Rice-wheat-mungbean	4.3	3.5	0.6	8.3	727.8	69
Rice-wheat-maize	4.0	2.8	2.5	9.3	783.3	81
Rice-mustard-maize	3.2	0.6	3.1	7.0	616.7	43
Rice-wheat-*Sesbania* sp.	3.0	3.3	-	7.3	555.6	29
Rice-wheat-fallow	3.5	3.2	-	6.7	55.6	29

[1]Compared with farmer pattern.

Table 10. Improved vs. farmer cropping patterns: irrigated lowland, Lele, Lalitpur, Nepal (avg. 1982-84).

Pattern	Crop Yield (t/ha)			Returns Over Variable Costs	
	Summer	Winter	Total	$/ha	Gain (%)[1]
Farmer					
Rice-wheat	3.4	2.4	5.9	583.3	-
Improved					
Rice-wheat	5.3	2.2	7.5	916.7	57

[1]Compared with farmer pattern.

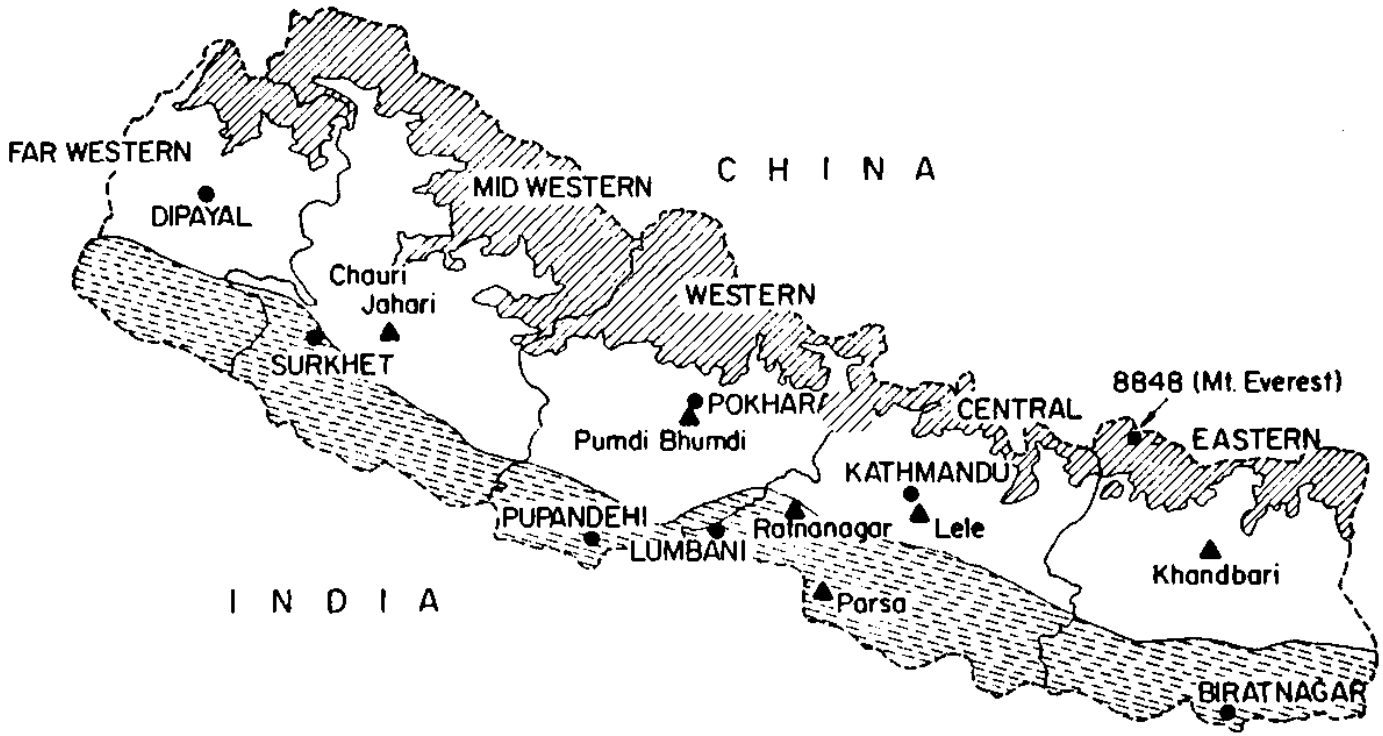

Fig. 1. Three major ecological zones and locations of cropping system sites in Nepal.

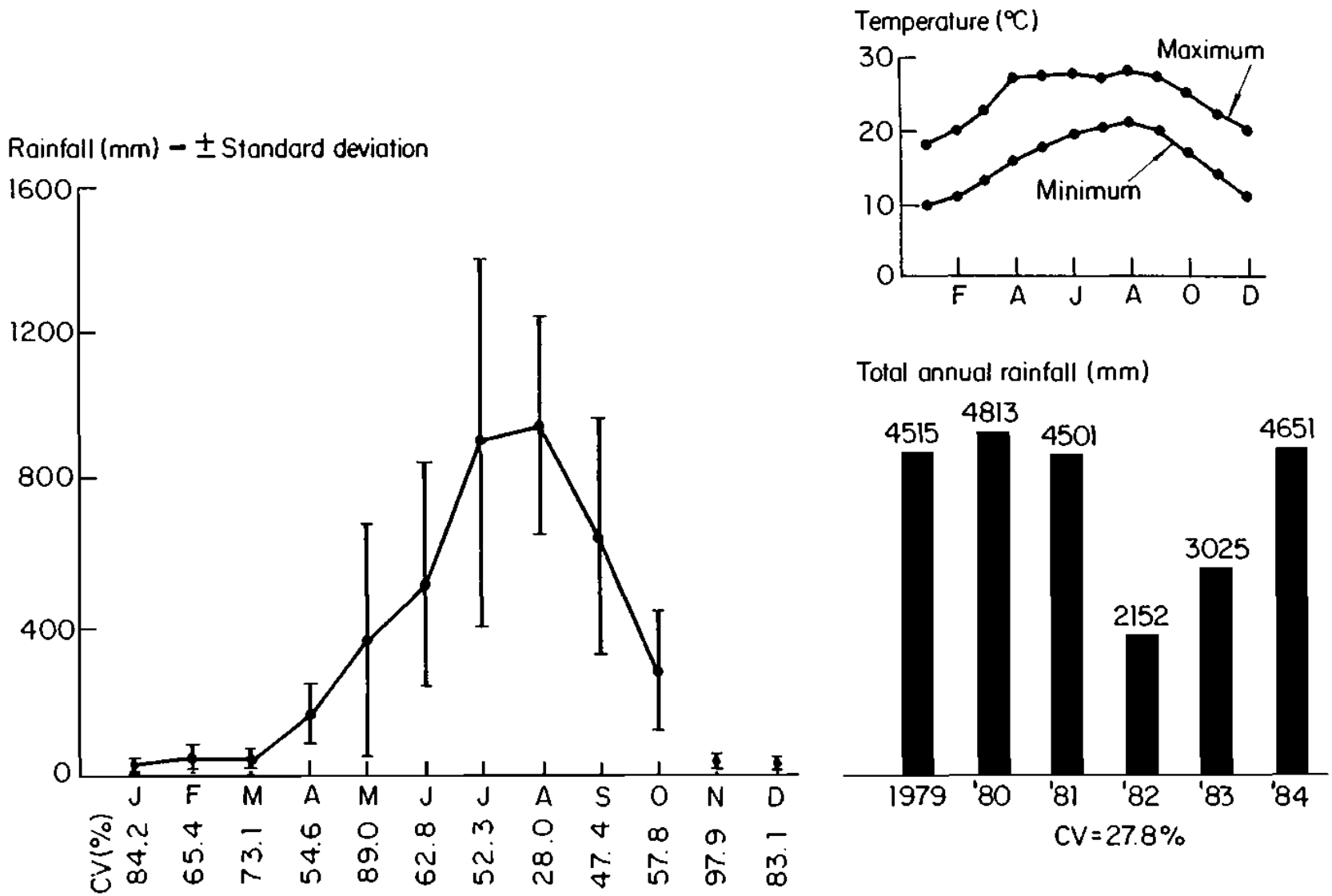

Fig. 2. Monthly rainfall and temperature means from July, 1978 to December, 1984, Pumdi Bhumdi, Nepal.

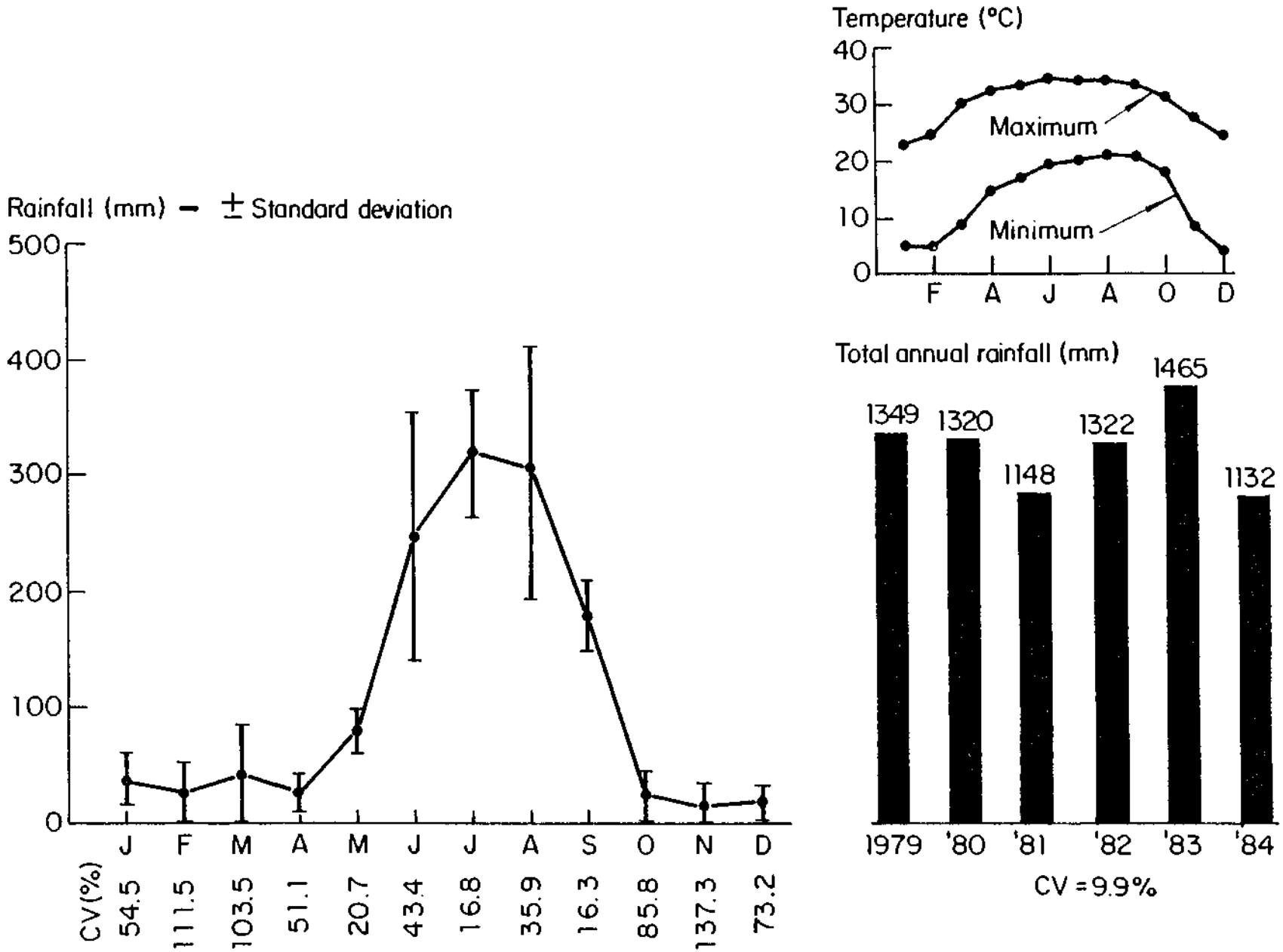

Fig. 3. Monthly rainfall and temperature means from July, 1978 to December, 1984, Chauri Jahari, Nepal.

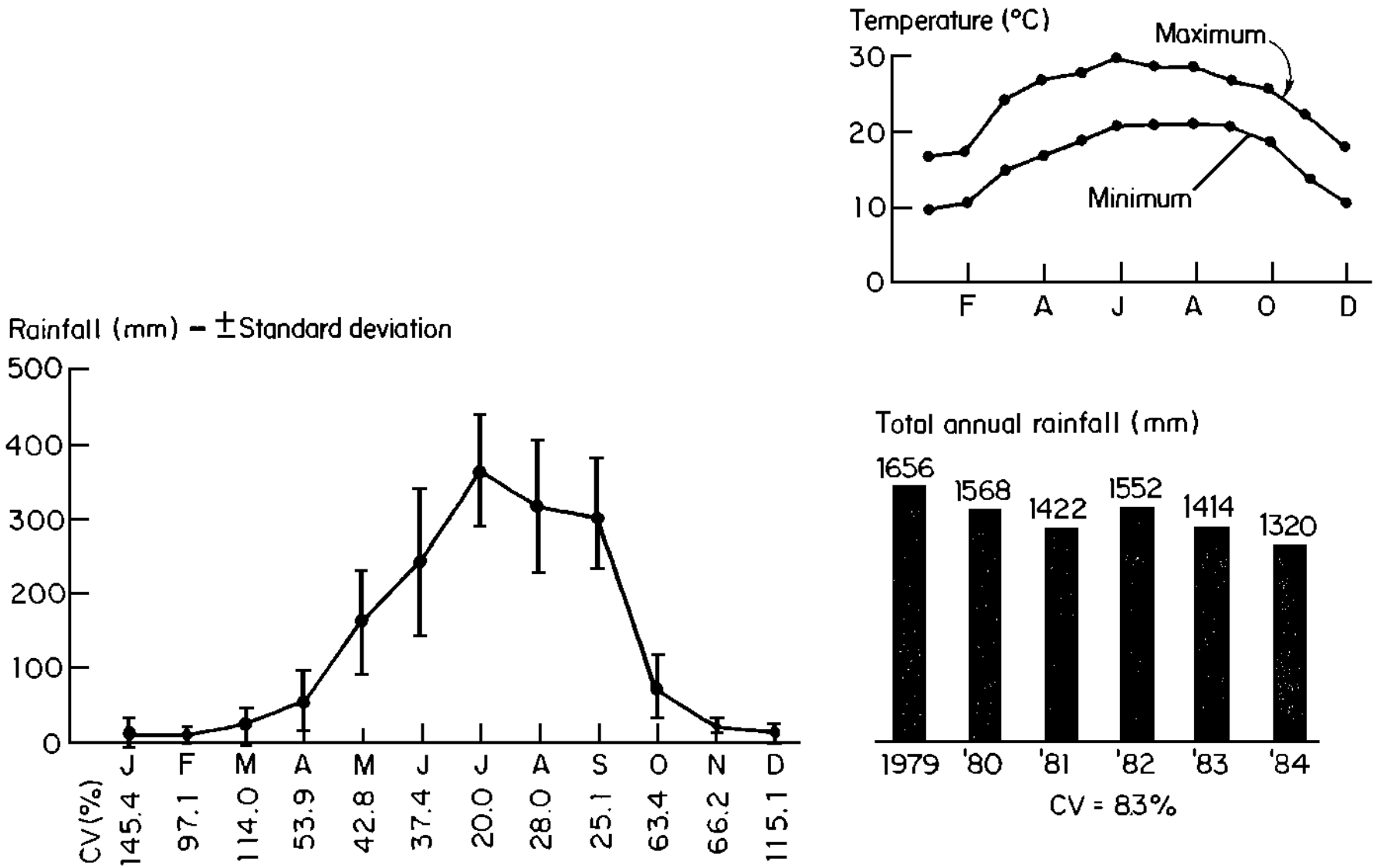

Fig. 4. Manthly rainfall and temperature means from July, 1978 to December, 1984, Khandbari, Nepal.

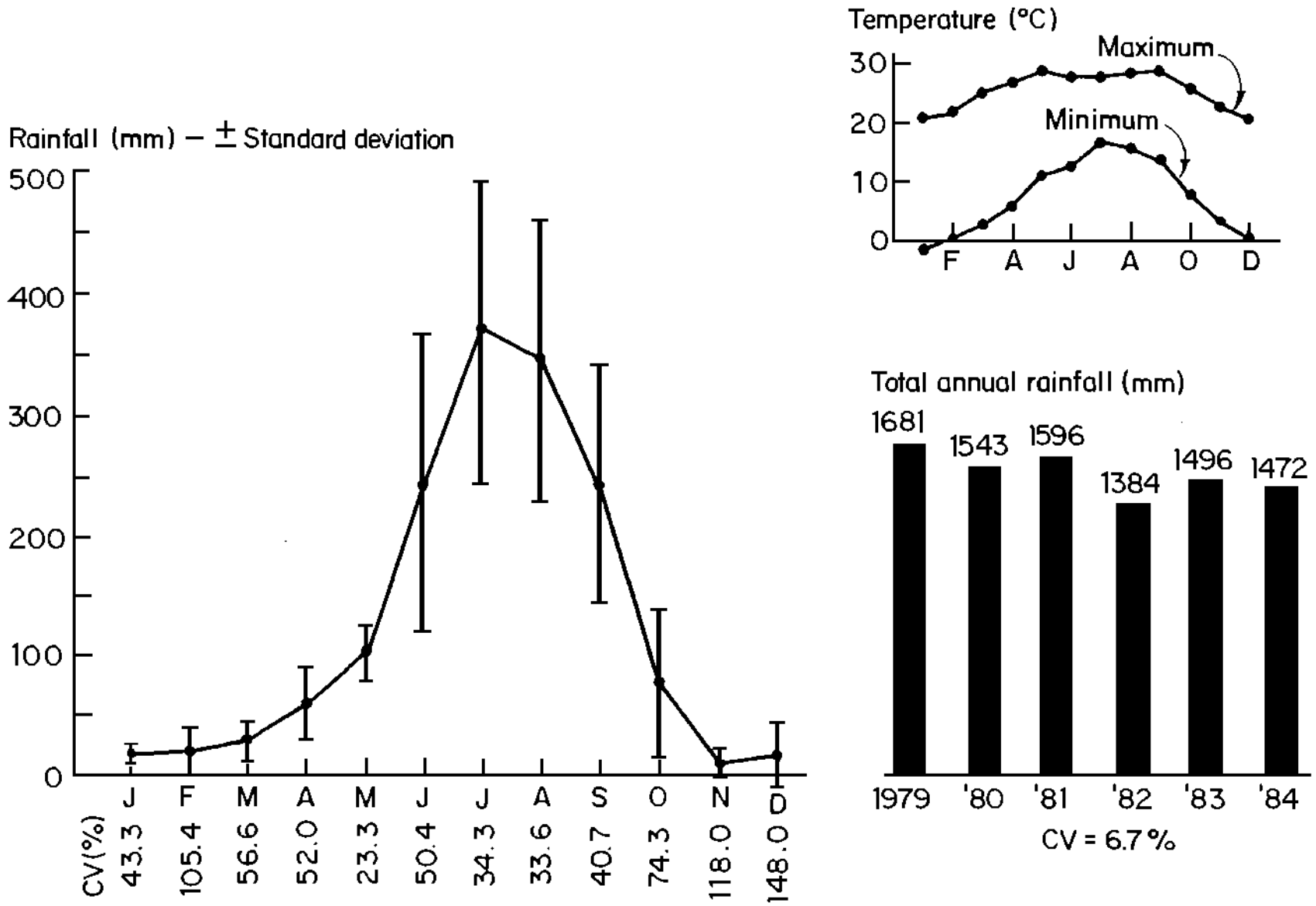

Fig. 5. Monthly rainfall and temperature means from July, 1978 to December, 1984, Lele, Nepal.

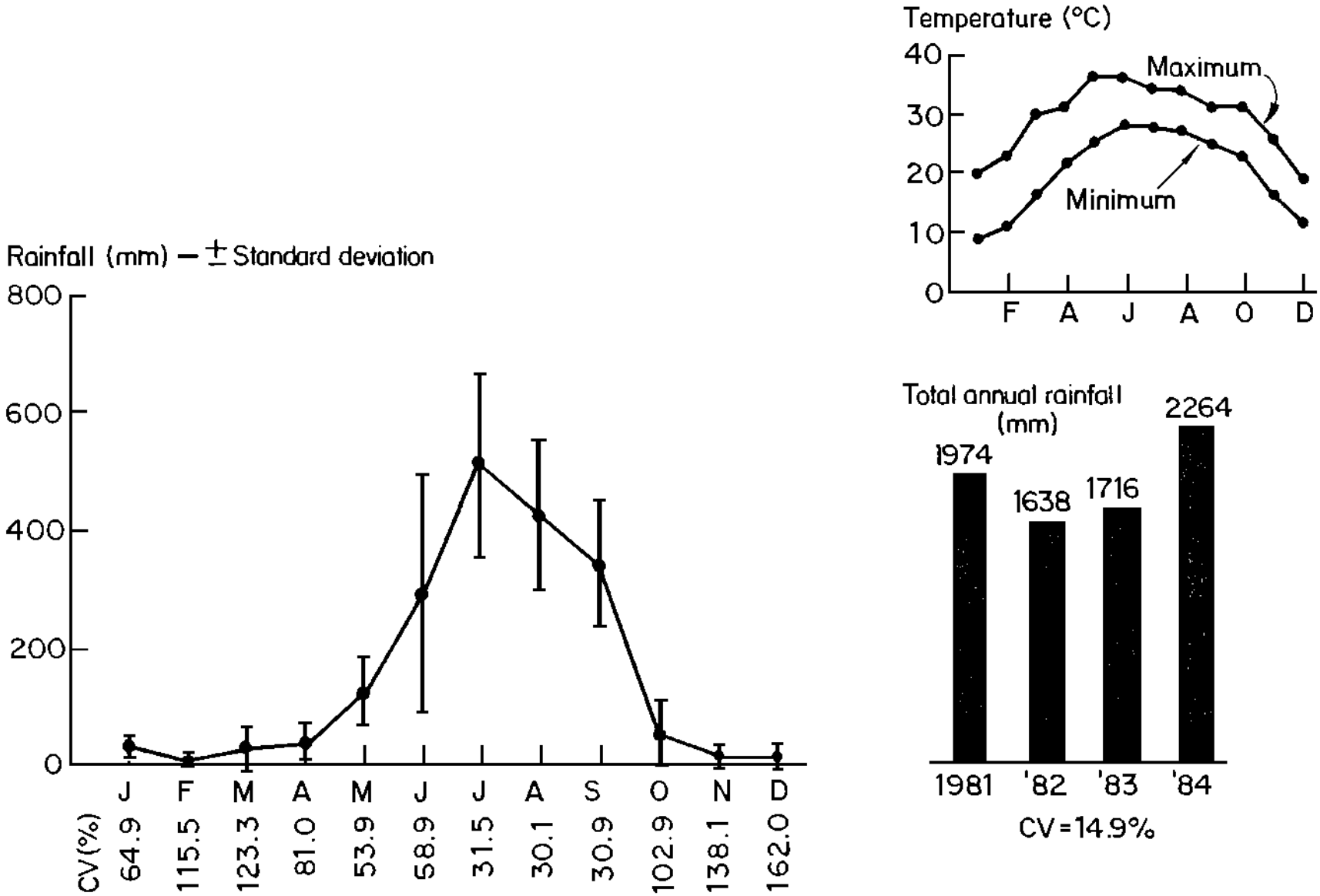

Fig. 6. Monthly rainfall and temperature means from September, 1980 to December, 1984, Ratnanagar, Nepal.

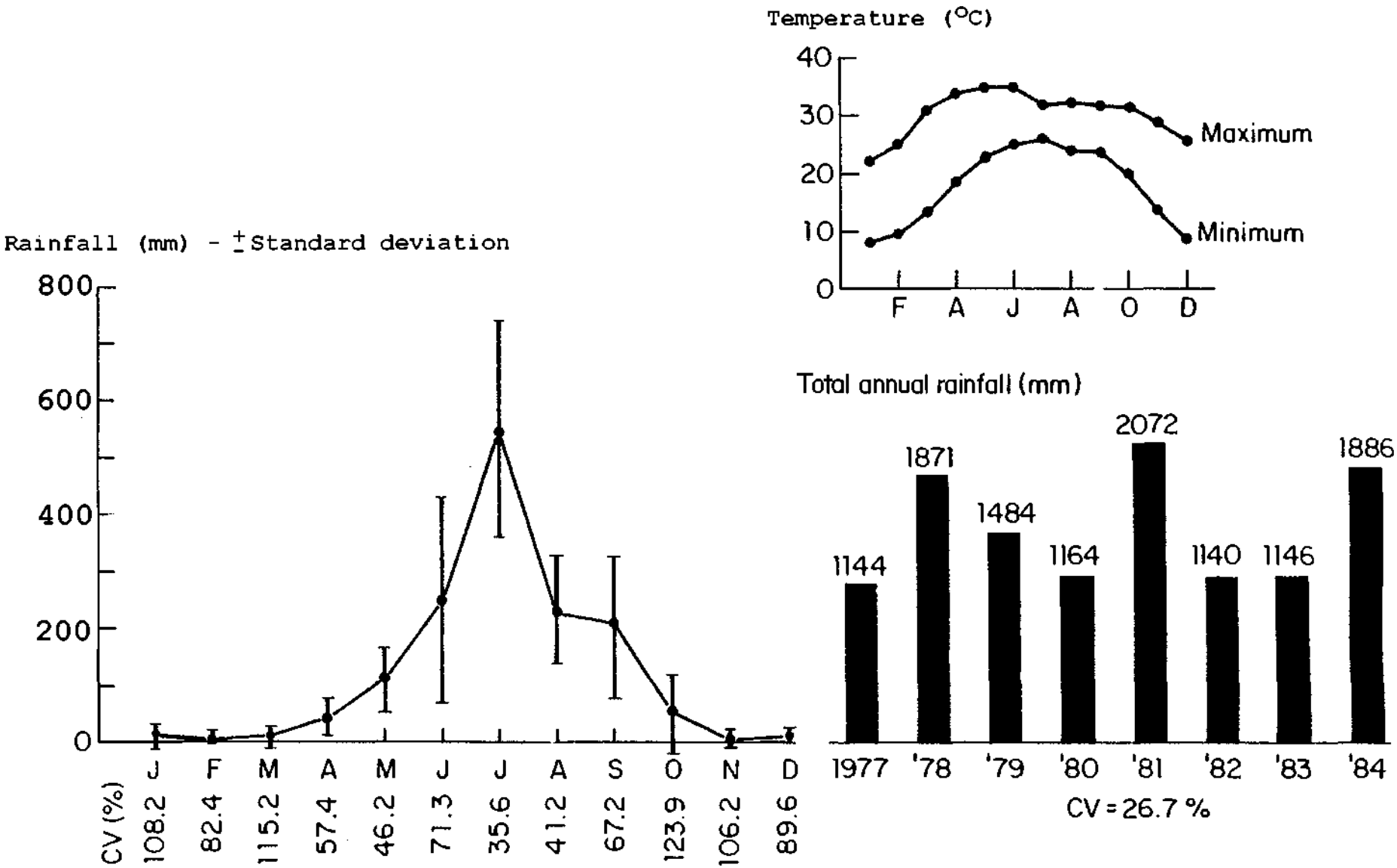

Fig. 7 Monthly rainfall and temperature means from January, 1977 to December, 1984, Parsa Nepal.

POTENTIAL OF ON-FARM RESEARCH TRIALS TO INCREASE CROP PRODUCTION ON SMALL FARMS IN NORTH ALABAMA[1]

U. R. Bishnoi, P. Mtshali and C. Sabota

ABSTRACT

In North Alabama, about 77% of all farms are classified as limited-resource farms. in 1985, three of these small farms were selected for on-farm research trials designed primarily to increase crop production through multiple cropping or by adapting new production techniques. On one small vegetable farm, early tomatoes were planted in and under plastic and were then followed by a fa!) cabbage crop. Black plastic with tunnel Remay increased earliness of marketable tomatoes by one week, and the plants yielded 56% more than non-mulched tomatoes. Cabbage planted after tomatoes produced over 20,000 kg/ha. The head weight and count were 30% higher in split-applied nitrogen plots than single application plots by the farmer. Research was also conducted on a corn and sorghum farm to compare grain yield responses of these crops to split applications of nitrogen fertilizer to one-time applications by the farmer. Split nitrogen applications (half at planting and half at the 4-5 leaf stage) for both crops produced over 33% higher yields in comparison to the farmer's rate and method of application. Similarly, to demonstrate yield differences due to row spacing and phosphorus rates, an on-farm research trial was conducted on soybeans. Results showed that soybeans yielded 32% higher in 45cm row spacing and with 23kg P205/ha than traditionally (90cm row with 68kg P2O5/ha) planted beans by the farmer. At the request of each farmer, these trials are being repeated in larger plots during 1986 growing season.

INTRODUCTION

It is now widely accepted that technological change is the basis for increasing agricultural productivity and promoting agricultural development. In the U.S., agricultural research is and has been primarily oriented to solve the problems of large farms. Technology developed from these research programs has greatly increased per land area production on large farms. The survival of small farms has been made more difficult because of large farms' economy of scale and their ability to explore market potential. High production costs of small farm owners, limited resources and their poor contact with extension agents make it difficult for their survival. In North Alabama, most of the small farmers can increase production from their small acreages through multiple cropping or by adapting new production techniques. Therefore, to help increase net returns and yields from these potential producers, three small farms (a vegetable, a soybean, and a com and sorghum grower) were selected to conduct on-farm research trials with the following objectives:

(1) To determine the efficacy of mulches on total yield of early planted tomatoes and production of a
second crop of cabbage.

(2) To evaluate the effects of row spacings and rate or methods of fertilizer application on yield of
soybean, corn and grain sorghum.

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[1]This work was supported in part by the OICD/USDA Grant No. 58-31-9R4-404. FSR/E Project.

MATERIALS AND METHODS

In Marshal County, an on-farm research trial included two early spring planted tomato varieties on a small vegetable farm. The effects of different mulches and/or row covers--black plastic (B.P.), tunnel Remay (T.R), slitted clear plastic tunnel (S.P.), and black plastic + tunnel Remay (B.P.+T.R.) were evaluated. In a multiple cropping effort and to determine the effects of split applications of nitrogen, cabbage was planted after tomatoes on July 23,1985.

Similarly on a corn and sorghum producing small farm in Limestone County, an on-farm research was conducted to compare grain yield responses of split applications of nitrogen to one-time applications by the farmer. Also, during summer of 1985, an on-farm research trial was conducted to demonstrate yield differences due to row spacing and phosphorus rates on soybeans. The planting procedures, seeding rates, fertilization, weed and insect control measures used were according to recommended practices. Horticultural or agronomic observations were taken and yield per treatment was recorded based on standard procedures set for each crop. Standard statistical procedures were used to analyze the data and means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Multiple Cropping -- Tomatoes and Cabbage

Height, earliness and yield data from the two tomato varieties are shown in Table 1. The plants in the combined black plastic and tunnel remay plots were significantly taller than plants in bare soil. The use of black plastic and/or row covers resulted in earlier tomato harvest by 6 days in Floradade and 9 days in Sunny in comparison to plants grown on bare soil. Such an advantage in earliness of tomato production has been observed by Coffeey (1984) in Tennessee. He also concluded that plastic mulch and row covers yield dividends to the grower in the form of earlier and larger yields, improved quality, and tower costs of production due to absence of weeds.

The data in Table 1 shows that the black plastic + tunnel remay resulted in more than a 70% increase in yield over the control (bare soil). Similar results have been reported by Brent & Wells as well as Taber in 1983. Brent and Wells reported that black plastic plus row covers increased total yields of tomatoes over that obtained from bare soil or black plastic mulch only. Taber (1983) in a related study on tomatoes and muskmelons reported that the effect on early production of tomatoes from plastic mulch plus row tunnel was greater than bare soil.

Nitrogen fertilizer trials often concentrate on rates, and forms of nitrogen application; however, split application has not been emphasized. Therefore, an on-farm trial on the use of split nitrogen in comparison to farmers practice of a one-time application at planting was conducted. To demonstrate the effects of split-applied nitrogen, a test on cabbage as a second crop after tomato was conducted during 1985. Results show that cabbage planted after tomatoes produced about 20,000 kg/ha and the head yields were (25,470 kg/ha) 29% higher in split-applied nitrogen plots than the farmer's single application plots (Table 2). This increase in yield resulted in almost $2,000 extra income per hectare to the farmer, In southern Alabama, increases in total farm productivity and income through double cropping have been reported by Andrews et at. (1983).

Split Nitrogen-Corn and Sorghum

In Limestone County, an on-farm trial was conducted to demonstrate the effects of the split-application of 36 kgN/ha (based on soil test recommendations) compared to the rate used by the farmer (18 kg/ha) on corn and grain sorghum. The results showed that a significant increase in corn height, ear length and yield was obtained with 50% nitrogen at planting and 50% applied 40 days after planting, in comparison to the farmer's rate (18 kg/ha) all applied at planting (Table 3). The yield from 50% /50% split N plots was also significantly higher than 33% applied at planting and 67% after 40 days of planting. Similar yield responses were observed in grain sorghum (Table 4). However, sorghum in split applied nitrogen plots in comparison to one-time application plots had no significant difference in height nor length of panicles.

In general, benefits of split-applied nitrogen are well established (Malzer et at. 1986) and are associated with reduced nitrogen loss. One-half of the nitrogen applied at planting helped in development of vigorous plants and the other half applied after 40 days promoted corn and sorghum ear/head development and thus contributed significantly in grain yield. These results are similar to those reported by Mitchel et al. (1984) in Alabama.

Spacing and Phosphorus Application — Soybeans

Since the yield of soybeans are affected by spacings among the plants and rates of phosphorus, an on-farm trial was conducted to demonstrate such effects on a soybean producer's farm in Madison County. The data are shown in Table 5. The results showed that soybeans yielded 25% higher in 45cm row spacings in comparison to traditional row spacing (90cm) used by the farmer. Different phosphorus rates did not have any significant effect on yield. In a similar study Parks and Manning (1980) reported a significant yield increase due to narrow row spacing in several soybean varieties. They reported a high yield of 67 bushels per acre for Essex in 45-cm row spacing in comparison to a low of 39 bushels per acre for Forrest in 90-cm row spacing.

CONCLUSION

These research trials have conclusively demonstrated that benefits are derived from the use of new production technologies and are justified even on U.S. small farms. However, since these results are from one crop season only, it is suggested that these trails be repeated and/or be conducted regionally before making a final recommendation to small farmers.

ACKNOWLEDGEMENTS

The facilities provided by Alabama A&M University, Normal, Alabama, the financial support from OICD/USDA and the constant encouragement from Dr. Hezekiah Jones, principal investigator of the project, are highly appreciated.

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Table 1. Effects of different Mulches on height, days to First harvest and yield of Two tomato Varieties

	Varieties					
	Floradade			Sunny		
Mulch Treatment	Height	First Harvest	Yield	Height	First Harvest	Yield
	cm	days	Kg/ha	cm	days	kg/ha
Black Plastic (B.P.)	47b[1]	81b	8,235e	46ab	81b	10,807d
Tunnel Remay (T.R.)	44bc	81b	11,985d	44bc	81b	12,297c
B.P. + T.R.	65a	81b	21,654a	50a	81b	21,602a
Slitted Clear Plastic	46bc	82b	13,626c	47ab	81b	12,316c
Control (bare soil)	41c	87a	19,789b	40c	90a	17,945b
Mean[2]	48a	82a	15,058a	45a	83a	14,993a
LSD 0.05	5.0	2.3	211.6	4.0	1.9	263.2

[1]Means within the columns followed by the same letter are not significantly different at 0.05 level of probability.

[2]Means of same parameters within varieties within the row followed by the same letter are not significantly different at 0.05 level of probability.

Table 2. Effects of split application of nitrogen on cabbage planted after tomatoes.

Nitrogen Rates	Cabbage Yield	Sale Value
Kg/ha	Kg/ha	$/ha
0+68[1]	19,712b[2]	6,505
34+34	25,470a	8,405
LSD 0.05	313.5	-

[1]The first figure denotes the amount applied at three weeks after planting, and the second figure denotes the amount applied six weeks after planting.

[2]Means within the columns followed by the same letter are not significantly different at 0.05 level of probability.

Table 3. Effects of split applications of nitrogen on corn production in Limestone County, Alabama.

Nitrogen rates	Ear length	Plant heights	Corn yield
kg/ha	cm	cm	kg/ha
18[1]	14b[2]	148b	1,774c
136[3]	17a	178a	5,193b
45+91[4]	20a	178a	5,410a
68+68	18a	175a	6,255a
LSD 0.05	2.2	2.7	198.9

[1]Farmer’s rate applied in one application at planting.

[2]Means within columns followed by the same letter are not significantly different at 0.05 level of probability.

[3]Recommended rate all applied at planting.

[4]The first figure represents the amount applied and the second figure represents amount applied 40 days after planting.

Table 4. Effects of splits application of nitrogen on grain sorghum production in Limestone County, Alabama.

Nitrogen rates	Panicle length	Plant height	Grain yield
kg/ha	cm	cm	kg/ha
18[1]	24a[2]	98a	3,487c
91[3]	26a	101a	4,218b
23+68[4]	25a	102a	4,316b
46+45	26a	102	4,631a
LSD 0.05	3.2	8.2	133.7

[1]Farmers rate all applied at planting.

[2]Means within the columns followed by the same letter are not significantly different at the 0.05 level of probability.

[3]Recommended rate all applied at planting.

[4]The first figure represents the amount applied at planting at the second figure represents amount applied 40 days after planting.

Table 5. Effects of row spacing and rates of phosphorus on soybean production in Madison County, Alabama.

Phosphorus rates	Row Spacings 45cm	90cm	Mean
kg/ha	kg/ha	kg/ha	kg/ha
23	2,970a[1]	2,103a	2,537
45	2,681b	2,294a	2,487
68	2,723ab	2,242a	2,483
Mean	2,791a[2]	2,213b	-
LSD 0.05	278.2		

1Means within the columns followed by the same letter are not significantly different at the 0.05 level probability.

2Means within the row followed by the same letter are not significantly differently at the 0.05 level of probability.

ASSESSING THE YIELD GAP FOR ALFALFA GROWN ON SMALL FARMS IN LARIMER COUNTY, COLORADO

Allan Fulton, Robert Hamblen, and W. R. Schmehl[1]

INTRODUCTION

A farming systems project needs flexibility if it is to use the client-oriented approach for solving farmer's problems. Mandated project objectives may compromise the holistic, interdisciplinary process of the approach. The objectives may be so rigid and specific that they do not permit feedback from farmers to influence research on solution to their real needs. Applied research conducted as a cooperative activity between farmers and researchers is proposed as being effective in addressing their priority needs in realistic ways. This report is an example of a project with flexibility to use feedback to guide the direction and output as the study progressed.

The initial goal of this project was to adapt certain on-farm testing methods that have become common with rainfed systems to irrigated farming systems, where they are often omitted. When used for irrigated systems the diagnostic analysis usually concerns solutions for implementation rather than objectives to be addressed. Consequently, the "solutions" recommended have had poor adoption rates. Thus, this project was initiated to develop on-farm irrigation research methods that could be used to test and identify improved water-management practices for alfalfa that would be accepted by small farmers in Larimer County. These practices would also provide information needed to improve management of the irrigation system. Based on interviews with Larimer County Extension personnel, it was initially assumed that poor water management was a constraint to alfalfa production in the target area. It was also assumed that farmers placed a high priority on improving their irrigation practices for alfalfa.

PROCEDURE

The interactions among physical, biological, economic, and social factors which influence farmer's adoption or rejection of new recommendations are complex in nature. For this reason, this study applied a holistic, farmer-oriented, problem solving approach (Schmehl, 1984) to understanding the reason for the gap between farmer and Experiment Station yields and how to reduce the production constraints. Six basic activities are involved when applying the problem-solving approach to agricultural research. A schematic of the research approach is provided in Figure 1. The activities include: 1) selection of the target area, 2) analyzing the farms for the system constraints, 3) designing and planning research needs, 4) conducting on-farm research, 5) analyzing the research results, and 6) extension of the results.

The study was initiated in 1984 with preliminary farmer interviews, the determination of available soil phosphorus on a few selected farms (Fulton, 1986) and third cutting yields of alfalfa. Since the 1984 descriptive phase did not provide adequate information to define the system, its constraints and opportunities, the 1985 study consisted for two simultaneous activities, a) the detailed descriptive phase and b) the on-farm testing phase.

The general objective of the descriptive phase was to collect physical, biological, economic, and sociological data to accurately describe the farmers' current alfalfa management practices. Consistent with the farming systems approach, the objectives of the descriptive phase were:

- to determine the extent to which current biological recommendations are being accepted and possible reasons for the rejection of other recommendations;

- to interact with growers and identify from their perspective production constraints which warrant further research and development;

- to determine homogeneity among farms selected for the study in terms of production constraints from the growers' perspectives, and to identify potential alternative solutions which appear acceptable to the growers and are effective in solving the constraints; and

- to use a better description of the system under study to assist in the analysis of the on-farm testing phase.

The 1984 preliminary testing phase did not provide sufficient information needed to design new or improved farm irrigation practices. Thus, the objective of the on-farm testing phase was to evaluate the differential effects of method of irrigation on the yield response to broadcast phosphate fertilizer. Based on the phosphate soil test, established alfalfa fields were selected which were expected to respond to phosphate fertilization. It was anticipated that different response levels in yield and plant phosphorus content as affected by method irrigation would identify the most effective irrigation method.

Because of limited funding, the formation of the usual interdisciplinary research team was not possible for this study. Consequently, the field activities were conducted by a graduate student in agronomy and an undergraduate technician. Resource persons included an advisory committee experienced in extension, agricultural economics and farming systems procedures. The graduate student had also taken a basic farming systems course and had experience in an interdisciplinary summer irrigation training program for Third World participants.

Selection of the target area

Target area selection was based upon three criteria: 1) prominence of the alfalfa enterprise in the farming system; 2) geographic and climatic similarities; and 3) to a lesser extent convenient access to the target area to reduce travel requirements.

After consulting with the local County Extension personnel, alfalfa was considered the appropriate crop for the study, because preliminary information indicated that farmers yields were only about 60% of those obtained on the research station and secondly, poor irrigation of alfalfa was considered by Extension personnel as a primary, urgent problem of the farmer.

The target area consists of small farms as defined by West (1982). It is located northeast of Fort Collins, Colorado and encompasses approximately 125 square miles. A map of the target area is shown in Figure 2. The northern boundary is Larimer County Road 80, approximately 12 miles from the Wyoming State border, while the southern border is less than 0.25 miles south of Colorado Highway 14. The western border is Larimer County Road 19 and the eastern boundary extends one mile past the Weld County line.

Climatic characteristics includes a frost-free season ranging from 130 days in the north to 150 days in the south. The short growing season restricts the cropping pattern to a single crop per unit of land per season. The long-term mean annual temperature ranges from 47 to 50°F throughout the research area, and the long-term average annual precipitation ranges from 13 to 18 inches, ascending from south to north. Elevation ranges from 5000 feet in the south to 5450 feet in the north.

Methods to analyze the farming systems and identify primary production constraints

Four mechanisms were employed in 1985 to analyze the farming systems and identify primary production constraints within the target area: 1) secondary information sources, 2) informal farmer surveys, and 3) field observations and measurements to monitor the farmer's field activities, and 4) on-farm testing.

Initial activities were limited to a reconnaissance survey in 1984. At the outset, however, limited farmer interviews indicated little evidence of direct farmer-input into the solution of their major production constraints by Experiment Station research.

Secondary information sources

Three sources of secondary information were available during the initiation of this study, they included the: 1) Larimer County Extension Service, 2) Colorado State University (CSU) Agronomy Department, and 3) USDA Soil Conservation Service.

The Larimer County Cooperative Extension Service identified the cropping enterprises within the target area that offered the greatest opportunity for production improvements and subsequent benefit to the farmers. Secondly, extension agents[2] provided valuable insights concerning production constraints of farmers in the target area based on personal contact. Lastly, together with the Experiment Station agronomists, the Extension Service provided the current recommendations for irrigated alfalfa (Table 1).

Experienced agronomists[3] at CSU provided Experiment Station results which supported the leading production constraints voiced by the Extension Service. Also, they provided advice regarding the most feasible biological solutions to the grower's constraints.

USDA Soil Conservation Soil Surveys were important sources of long term climatological statistics, topographical characteristics, and taxonomical classification and description of the soils in the target area. The soil survey maps were used to identify soil series for collecting samples.

Informal farmer surveys: The informal survey method was used because the participating farmers seemed more at ease when answering questions, and the procedure was flexible to meet the participating farmer's busy daily schedule. Informal discussions for the 1985 study were limited to those farmers participating in the irrigation/fertilizer trials. First, general background information was obtained with regard to their entire farm system. Second, more specific information regarding the alfalfa enterprise was obtained.

The general farm background information obtained each farmer was: 1) acreage of cultivated land, 2) types and acreages of crops produced, 3) years involved with farming, 4) farm management goals and objectives, and 5) opinions, beliefs, and attitudes towards accepting change into their current farm system and management practices.

Information was also obtained from each farmer regarding the role of the alfalfa enterprise in their farm system. Such information included: 1) production goals, 2) production costs, 3) the role of alfalfa in their cropping pattern and 4) the outlook for alfalfa production in terms of value and marketability. More specific questions pertained to the eleven alfalfa fields where the trials were located, e.g.: 1) previous crop, 2) procedures used to establish alfalfa, 3) past fertilizer applications and pesticide treatments after stand establishment but prior to the 1985 season, 4) leading production constraints from the growers' viewpoint, and 5) the growers' responses to current Extension Service recommendations for irrigated alfalfa (Table 1).

On-farm irrigation-fertilizer trials

Selection of alfalfa fields for trials

During the late summer and fall of 1984 and the early spring of 1985 soil samples from the plow layer were collected by series from 26 established alfalfa fields within the target area. All soils were non-saline, calcareous and ranged from sandy clay loam to clay loam in texture. Available water holding capacity increased from 0.11 to 0.17 inches of water per inch of soil with increasing clay content. The samples were air-dried and analyzed for available soil phosphorus using the sodium bicarbonate soil test (Olsen et al., 1954). The corresponding NH4HCO3-DTPA soil test level can be calculated by dividing the $NaHCO_3$ soil test level by two (Soltanpour and Schwab, 1977).

The eleven fields selected for the on-farm tests were based on two criteria: 1) irrigation method and 2) soil test level. These fields represented nine farmers within the target area and four irrigation methods, three flood, and four side-roll, three center-pivot and one solid-set sprinkler. Based on the recommendations from the soil test (Soltanpour et al., 1985) all fields selected required an application of 200 pounds P_2O_5 or more for three years production (Table 2) or 100 pounds P_2O_5 or more for one year. The trials were located within each field on the area which had the lowest soil test index (Table 2).

Treatments and experimental design

A 3 x 3 factorial which utilized a randomized complete block design was employed for all eleven researcher-managed irrigation/fertilizer trials. Three

levels of P_2O_5 (0, 125, and 250 lb, P_2O_5/A) were replicated three times for a total of nine plots per field. Each plot was 12 feet wide and 25 feet long. Thus, the total dimensions for a trial were 36 feet wide by 75 feet long. Four red corner stakes were driven down to the soil surface to provide permanent markers for each trial. The growers harvesting equipment passed freely over the markers. The fertilizer was applied by broadcasting 45 percent super phosphate in the spring at each site while the alfalfa was still dormant.

Yield and phosphorus content

Forage harvests were arranged with each participating farmer so that cuttings were made just prior to the farmer's harvest. Instances occurred where there was considerable rain between the experimental harvest and the farmer's harvest which caused a noticeable gap between harvest dates. Three cuttings were made on all of the trials.

Two 30-inch swaths, each 22.5 feet in length, were cut in each plot. The alfalfa was collected for each plot and green weight was recorded in the field. Then, plant sub samples representing each plot were collected, oven-dried at 150°F for 48 hours and weighed to obtain oven dry matter. The plot weights were then adjusted to 15 percent moisture and converted to tons per acre. Dried plant sub samples were analyzed for total plant phosphorus (Havlin and Soltanpour, 1980).

Analytical methods

The Colorado State University Statistics Laboratory computer package STAT41V was used to analyze the data as a combined location analysis of variance. Although time of cutting was not a designed treatment, individual cutting and seasonal alfalfa yield data were analyzed. The Cate-Nelson graphical method (Nelson and Anderson, 1977) was employed to relate the soil test analyses to relative alfalfa yield. The relative yield (RY) was calculated using the equation,

$$RY = \frac{\text{Yield with phosphorus}}{\text{Yield without phosphorus}} \times 100$$

Thus, RY gives the phosphate response relative to the no-phosphate treatment.

An assessment of the farmer's current irrigation practices was conducted on each trial to determine whether irrigation management was a potential constraint on alfalfa production. The evaluation (Fulton, 1986) was done in five steps: 1) available water holding capacity and soil texture were determined, 2) residual winter soil moisture was calculated, 3) rainfall during the growing season was measured, 4) depth of each irrigation was measured and 5) post-dormancy seasonal alfalfa evapotransporation (ET) was calculated (Jensen, 1973).

Economic analysis

Partial budget analysis (Osburn and Schneeberger, 1978) was used to examine the cost effectiveness of the current soil test recommendations based on the 1985 seasonal yield-response data.

RESULTS

The role of the alfalfa enterprise in the target area

Alfalfa was either the sole crop or accounted for the largest crop acreage produced by each farmer participating in the study. Seven of the nine participating growers sold nearly all their alfalfa hay to generate their major source of farm income. The farmers' 1985 season yields for the eleven fields under observation averaged approximately 4.4 tons as compared with about 6 tons per acre on the local Experiment Station. Therefore, the results revealed, as presumed early-on, that 1) alfalfa was the main cash crop for these farmers, and 2) there was considerable potential for increasing yields through improved management practices.

The growers emphasized that their major production objective was to maximize profits from the alfalfa enterprise. In order to achieve their objective they expressed an unwillingness to accept recommendations unless they were reasonably certain that they would net a benefit. The farmers stressed that they were operating with limited capital and access to credit so they preferred to invest in practices which would bring the greatest return to investment with minimum risk within one year from the time of investment.

Identification of primary production constraints and assessment of acceptance of recommendations

The growers unanimously identified untimely rainfall at harvest as the leading production constraint for alfalfa. During the 1985 season it was observed that over 40 percent of the participating farmers' harvests were interrupted by rainfall when the alfalfa was laying in the field. Inopportune rainfall was costly in both yield and quality. First, rainfall frequently delayed the scheduled harvest, so the alfalfa crop matured past the recommended 10 percent bloom stage when the optimum combination of forage yield and protein content is obtained. Moreover, the delay would often cause several fields to mature at the same time and increase the need for more labor and harvest machinery. Secondly, rain which occurred while the alfalfa was curing prolonged the field drying process. The delay often caused the cut hay to deteriorate which reduced the yield and protein content. Subsequent new growth was also reduced by delayed removal of windrows. Lastly, because of first and second cutting delays, the third cutting growing period was so reduced that the area growers were fortunate to harvest a third cut, not to mention a recommended fourth cutting.

The producers ranked irrigation as their second leading production constraint. Farmers who used either canal or well water cited limited water resources as the reason irrigation management has been a major constraint on alfalfa production. Calculated water requirements and measured irrigation and rainfall for the 1985 season would seem to support the growers contentions. Crop ET (Jensen, 1973) calculated for the eleven fields under observation exceeded the total depth of available water from irrigation, residual soil moisture and precipitation by 6.6 to 21.1 inches for the 1985 season (Table 2). Yield measurements indicated that the growers were producing one ton of cured hay with two to four inches of water which is considerably less than the six inches of water usually required to produce one ton of cured hay (Table 1). Even though the calculations indicated that under irrigation was a likely constraint on production, only one field (trial 1) showed severe foliar symptoms of drought stress.

Opportunities to introduce rapid change into the farmer's current irrigation practices appeared minimal for three reasons: 1) inconsistent and limited water resources were beyond the farmer's control, 2) the extensive alfalfa tap root absorbs subsoil moisture from supplies well below five feet which enables the crop to withstand apparent under irrigation, and 3) the growers seemed outdated with respect to modern irrigation technology compared to their knowledge of other biological management practices.

The participating growers expressed a willingness to plant improved varieties with greater yield potential, but they wanted results from variety trials conducted under a production environment more representative of their farm environment. The growers did not believe that the improved varieties identified in Experiment Station trials would perform the same in their production environment. In addition, they were interested in results which indicated how the new varieties would perform beyond the three or four full-production years on the Experiment Station trials.

Planting rates ranged between six to fourteen pounds of seed per acre. The farmers expressed interest in reducing planting rates because of increased costs of new varieties. Consequently, the recommendation to plant alfalfa in the summer gained support from the growers because seeding rates were reduced since the alfalfa seedlings did not have to compete with the oat cover-crop for moisture and nutrients. Two other advantages of the summer planting recommendation were cited: 1) time would be available to produce a rapid maturing, short-season crop which was more marketable than traditional oat hay, and 2) the traditional oat windrows would be eliminated which shade the alfalfa seedlings and harbor damaging alfalfa insects while the oat hay is curing.

The growers did not respond favorably to the recommendation to plow-up alfalfa stands after the fourth full-production year. They emphasized that they did not believe the yield losses to age of stand after the fourth full year of production were greater than the costs required to establish a new stand. Achieving maximum yields by maintaining younger stands would not, in their opinion, necessarily maximize profits.

All of the farmers reported that phosphate deficiency was their major nutritional concern when producing alfalfa. However, only one grower consistently used soil tests to determine fertilizer requirements. All other growers indicated that they have used soil tests occasionally but cited three reasons for discontinuing their use: 1) farmers observed inconsistencies between recommendations from different laboratories for sub samples representing the same soil, 2) when recommendations were followed they frequently observed little or no response, and 3) limited cash flow has forced them to invest in other inputs which they believed give a greater return to their investment, as for example, the use of hay preservatives at harvest.

All of the farmers suggested that insects, weeds, and diseases were minor constraints to alfalfa production. Weeds seemed to present the greatest problem during the year of establishment but were effectively controlled by frequent cutting and later competition from alfalfa. During the 1985 season, alfalfa webworm and alfalfa weevil were observed as prominent alfalfa pests. The growers effectively controlled the pests by spraying with Furidan or Lorsban after the first cutting. Disease resistant varieties were reported to be effective in controlling common alfalfa diseases.

Phosphate fertilizer effects under three methods of irrigation

Yield and plant phosphorus responses to phosphate as affected by irrigation method were ineffective in identifying how to improve the farmer's irrigation practices. Three of the eleven trials were deleted from the study because of a poor alfalfa stand (trial 10), stem nematode (trial 6) or because the farmer applied phosphate over the trial area (trial 3). Only two of the eight remaining locations (trials 4 and 8, Table 2) used for the analysis showed positive yield responses to phosphate fertilizer applications and there was no apparent association with the method of irrigation. One of the responsive locations under flood irrigation (trial 4) received 11.1 in. rainfall but no supplemental irrigation water. Yield increases of 28.8 and 37.3 percent were observed for the 125 and 250 P_2O_5 fertilizer rates, respectively. The other responsive location was irrigated with 12.3 inches water by center pivot sprinkler 25 times during the 1985 season in addition to 9.3 inches from rainfall. Yields increased 25.9 and 34.8 percent for the 125 and 250 P_2O_5 fertilizer rates, respectively.

Four of the eight locations displayed significant increases in percent phosphorus content with phosphate fertilization. Two of the responsive locations were irrigated by center-pivot sprinkler, one by side-roll sprinkler, and one by flood. Three of the four non-responsive locations showed an increase in percent phosphorus content with increased fertilizer applications but not at five percent probability levels. Thus, it was evident that broadcast fertilizer was effectively absorbed by the alfalfa irrespective of the irrigation method, and the lack of response was not the inability to get phosphorus into the plant.

Consequently, the lack of yield response on six presumably phosphorus-deficient alfalfa fields and the farmers' reports of a lack of response led to the analysis of yield response versus soil test levels using the graphical method of Nelson and Anderson (1977). This method identifies, by quadrant, the responsive (upper left) and non-responsive (lower right) soil test levels when plotted against relative yield (Figure 3). For the best relationship, the other two quadrants should have no data points. Trials 4 and 8 fit into the response quadrant and all the remaining trials, except one, are in the non-responsive quadrant. Trial 1, with a soil test level of 6.6, was unique and the data point was in neither the responsive or non-responsive quadrant. As noted previously, trial 1 was the only trial where severe foliar moisture stress was observed. Apparently, severe moisture stress was limiting growth more than phosphorus deficiency.

The relative yield for the season plotted versus soil test level using the graphical method indicated a critical soil test level of about 7.8 ppm P (Figure 3). This critical level is comparable to the original soil test indices obtained in greenhouse studies by Olsen et al., (1954) who reported a probable alfalfa response when $NaHCO_3$ soil test levels are below 10 ppm P. Moreover, using the same graphical procedure, a critical level of 8.3 ppm NaHCO3 soil test phosphorus was determined (Figure 4) for six phosphate fertilizer studies conducted from 1955 through 1985 and representing 20 locations throughout Colorado (Schmehl et al., 1955; Schmehl and Romsdal, 1963; Hoff and Dotzenko, 1968; Fixen and Ludwick, 1983; Havlin, et al., 1984; Fulton, 1986).

The maintenance approach for phosphate fertilizer recommendations for three years alfalfa production was introduced at CSU in 1973. According to this philosophy, phosphate is applied at a rate to prevent its becoming limiting to plant growth over the ensuing three-year period. To meet the three-year requirement,

phosphate fertilizer is recommended when the soil test level is 30 ppm P or less (Ludwick and Reuss, 1974). The present study and the earlier studies provide considerable evidence that the probability of a yield response the year of application is unlikely unless the $NaHCO_3$ soil test level is less than 8 ppm P. The maintenance philosophy is still reflected in current recommendations as adjusted for the current NH4HCO3-DTPA test indices of Soltanpour et al. (1985).

A review of prices shows that the cost of phosphate has increased 270 percent while alfalfa prices have increased only 50 percent since 1973 when the maintenance philosophy for making phosphate fertilizer recommendations on irrigated alfalfa was established. It appears questionable whether the maintenance philosophy which was developed when fertilizer costs were relatively much lower remains appropriate in the present economic environment. Growers in the target area state that they must obtain a yield response to phosphate fertilizer the year of application in order to make best use of their limited resources.

A partial budget analysis for the 1985 study showed substantial economic benefit from phosphorus applications for the two responding locations (trials 4 and 8) with soil test levels of 6.6 ppm or less (Table 3). The one year recommendation (125 lb P2O5) would net $12.90 per acre at responsive locations, but the 250 lb P_2O_5 maintenance rate would net a $8.63 loss the first year. Over three years the maintenance rate would net $101.

Contrastingly, the analysis showed net losses or minimal returns for the locations with $NaHCO_3$ soil test levels above 6.6 ppm P (Table 3) because of a lack of first-year yield response. The growers at the non-responsive locations would lose approximately $26.46 per acre by following the one year recommendation. Likewise, the growers would lose $51.31 per acre for the first year of the three year maintenance recommendation. Assuming that a 36 percent total yield increase would be observed for the three-year recommendation at these non-responsive locations over the 1986 and 1987 seasons, the growers would net only $22.33 per acre for the three-year period.

It appears that the maintenance philosophy, adopted in 1973 when fertilizer prices were lower, has not recognized the non-proportional inflation of fertilizer prices compared to alfalfa market prices since 1973. A comparison of the benefits or loss from maintenance fertilization for the years 1973 and 1985 is shown in Table 4. The first-year cost of maintaining non-responsive soil test levels when applying recommended rates was about 6 times higher in 1985 than in 1973. The return to investment after three years averaged 16.3 percent and 7.4 percent per year for 1973 and 1985, respectively.

ANALYSIS OF RESULTS

Feedback to the Experiment Station

Methods of hastening the curing process of alfalfa hay appear to offer the greatest technological opportunity for alfalfa production. The use of drying agents which reduce the time required to cure the hay seems most acceptable to the growers, because it allows them to produce low-moisture, high-protein hay which often earns bonus prices. The growers were unaware of such commercially available products during the 1985 season. Moreover, they requested further research on the effects of

drying agents on the nutritional quality, palatability, physical appearance of the final product, cost of maintaining harvesting machinery and equipment, and the cost effectiveness of applying drying agents.

A re-evaluation of the current philosophy for making phosphate fertilizer recommendations on irrigated alfalfa is warranted. Economic feasibility and farmer's production objectives should be given greater consideration when using soil test levels to make phosphate fertilizer recommendations for the alfalfa growers. There is adequate information to make a rapid adjustment in these recommendations.

Immediate on-farm testing opportunities

On-farm testing of improved varieties under the grower's more adverse production environment provides a major opportunity for future on-farm research and development. Three characteristics of the improved varieties need further assessment. First, an evaluation of yield potential for the improved varieties under the grower's more adverse production environment would give the growers more confidence in the new varieties' performance levels. Secondly, on-farm trials are needed which assess the longevity of the improved varieties beyond four full- production years. The varieties which show the least decrease in yield with age of stand, yet have competitive yield potentials, would appear to be most acceptable to the growers. Lastly, the new varieties need to be assessed for possible drought tolerance at germination and emergence to identify the high performing varieties suitable for summer planting.

Opportunity exists to introduce a short-season crop to precede a summer planting of alfalfa. The growers are interested in rapid maturing crops which have a greater market value than oats used traditionally as a spring-planted, forage nurse crop.

Continued evaluation of method and amount of irrigation as a possible production constraint is warranted. Soil moisture contributions from the subsoil beyond the depth of five feet need to be assessed to establish irrigation requirements for alfalfa production in the target area. The alfalfa tap root has the ability to absorb considerable deep subsoil moisture, thus under irrigation is not as restrictive to production as the calculated crop ET, irrigation, and rainfall results indicate.

Extension recommendations

An immediate change in phosphate fertilizer recommendations based on soil test levels should be implemented because the current nutrient maintenance philosophy is not applicable to present-day economic conditions of the farmer. The yield response results of the 1985 trials were consistent with all past on-farm trials, thus there is adequate research information to make a rapid adjustment in recommendations. Phosphate fertilizer rates should be adjusted so that fertilizer is not recommended unless a first-year yield response of 30 percent or more is anticipated on the basis of the soil test. The farmer, on occasion, may obtain a small phosphate response the year of application when based on higher soil test level, but the yield response probably will not pay the cost of fertilizer. Even if the response gives a net profit after three years, an alternate use of the farmer's limited cash for other

higher return practices may be a sounder practice and may involve less risk. It is also the most probable practice the fanner will use.

Secondly, the season yields for the control (no phosphorus) treatments at all except one location were comparable to yields expected for adequately irrigated alfalfa. The lack of a relationship of yield to total water supplied by irrigation plus rainfall, or to method of irrigation, suggests that under irrigation is not a constraint to alfalfa production and that subsoil moisture meets much of the crop water requirement. Recommended irrigation practices must, therefore, take deep subsoil moisture into consideration.

General conclusions

In addition to the technical conclusions already noted, several general conclusions are appropriate for the applied agronomy researcher. Based on experience of this case, it appears both farmers and researchers are likely to benefit from 1) a flexible definition of research objectives and topics of focus and 2) the inclusion of complementary social science procedures such as farmer interviews to provide both a basis for defining and redefining the research, and also to help explain and interpret technical research results more completely. Although initial objectives of the researchers should not normally be abandoned midstream, they should be complemented by additional ones as they appear relevant, and researchers should remain open to signs that redirection may be appropriate. In this way, on-farm tests and the resulting recommendations are more likely be adopted, and will help to reduce the Experiment Station, farm-production yield gap. Also, the value and support of agronomic research are likely to become greater.

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FOOTNOTES

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2 Personal communication, 1985. G. Knott, Larimer County Extension Director and B. Hamblen.

3 Personal communication, 1985. Mark Brick and S.M. Workman, Assistant Professor and Research assoc., respectively, Department of Agronomy, Colorado State University.

ACKNOWLEDGEMENT

The authors acknowledge Dr. Ed Knop, Department of Sociology, for his contributions and constructive comments in the preparation of this paper.

Table 1. Production practices recommended by the Extension Service for irrigated alfalfa in the target area*.

- The selection of improved commercial and public varieties to replace the traditional varieties.
- Spring-plant alfalfa with oats as a companion crop or solo plant alfalfa in the late summer.
- Incorporate a three-year supply of phosphate fertilizer at planting or top-dress on established stands using the soil test as a guide to determine need and application rate.
- Incorporate a herbicide prior to planting or while the established stand is dormant for best weed control;
- Apply six inches of water for one ton of cured hay;
- Harvest alfalfa t about 10 percent bloom and make four cuttings pre season.
- Encourage growers to consider re-establishing the stand after four full-production years.

*Brick et al., 1984.

Table 2. Trial location results arranged according to $NaHCO_3$ soil test levels.

Trial No.	Soil test level ppm	Recommended P_2O_5 1b/A †	Method of Irrig	Relative Yield	Crop ET	Irrig Applied	Total Water**
					---------	--Inches--	---------
4	2.7*#	250	Flood	133	32.3	0.0	11.1
8	6.6*#	250	Center Pivot	130	35.0	12.3	21.6
1	6.6	250	Flood	108	31.3	6.1	17.4
3	7.4	200	Side Roll	(-)	35.0	17.5	28.4
5	8.0	200	Center Pivot	101	32.5	10.6	22.1
7	8.4#	200	Center Pivot	109	36.5	16.9	26.2
9	8.4	200	Flood	98	31.4	5.2	15.0
6	8.8	200	Side Roll	(-)	31.2	12.7	21.7
10	9.6	200	Side Roll	(-)	33.4	13.7	21.5
2	10.9	200	Side Roll	101	34.8	15.3	25.6
11	14.0#	200	Solid set	104	32.1	12.3	21.4

* Significant yield response to phosphate application.
\# Significant percentage phosphorus response to phosphate application.
** Rainfall, irrigation and residual soil moisture.
† Recommendation for three years based on the soil test level.
(-) Deleted from the phosphate evaluation study.

Table 3. Summary of the partial budget analysis for two phosphorus-responding locations and six non-phosphorus-responding locations using 1985 production prices.

Rate (lbs P_2O_5/A)	Total Benefit	Variable Costs	Benefit or Loss from Fertilizer[1]	Rate of Return to Fert. Invest. (%)
	($/A)			
	Responsive locations combined			
0	244.35	0	-	-
125 (1st year)	257.25	54.60	12.90	+23.6
250 (1st year)	235.72	97.06	-8.63	-8.9
250 (3 years)[2]	345.36	138.98	101.01	+72.7
	Non-responsive locations combined[3]			
0	330.75	0		
100 (1st year)	304.29	32.54	-26.46	-81.3
200 (1st year)	279.44	64.14	-54.31	-80.0
200 (3 years)	353.08	92.08	+22.33	+24.2

[1] The non-fertilizer treatment was used as the base to calculate the benefit or loss from phosphorus applications.

[2] The benefits and costs for the second and third years were discounted to 1985.

[3] Calculations based on 200lb P_2O_5 per acre, the current recommended maintenance rate when the soil test level ranges from 8 to 14 ppm P for the $NaHCO_3$ method (see Table 2).

Table 4. The benefit or loss from maintaining non-responsive soil test phosphorus levels using production prices in 1973 versus production prices in 1985.

Fertilizer Rate (lbs P_2O_5/A)	1973 Benefit[1] or Loss from Maintenance ($/A)	1985 Benefit[1] or Loss from Maintenance ($/A)
	Non-responsive locations[3]	
100	-6.74	-26.46
200 (1st year)	-8.53	-51.31
200 (3 years)[2]	+49.55	+22.33

[1] The values are in “normal terms”. This means that no indexing adjustments for inflation have been made to convert 1985 dollar values to 1973 dollar values. Suck an adjustment would have further magnified the losses from maintaining non-responsive soil test levels in 1985.

[2] Assumed a total yield response of 36 percent over the no P fertilizer yield would occur during the second and third growing seasons, based on 1985 yield responses.

[3] Calculations based on 200 lbs P_2O_5 per acre, the current recommended maintenance rate when the soil test level ranges from 8 to 14 ppm P for the $NaHCO_3$ method (see Table 2).

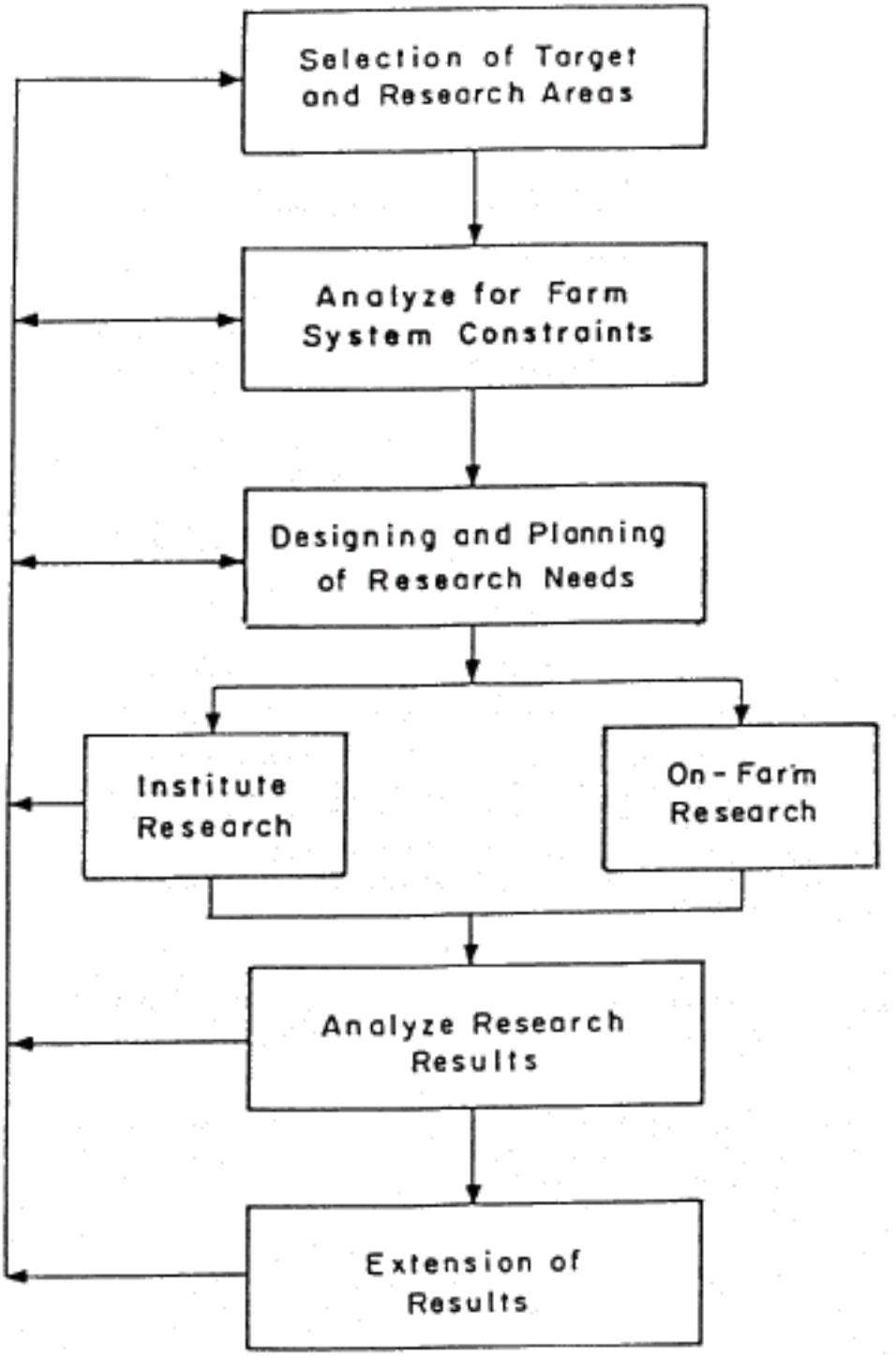

Figure 1. Basic activities of the problem-solver approach.

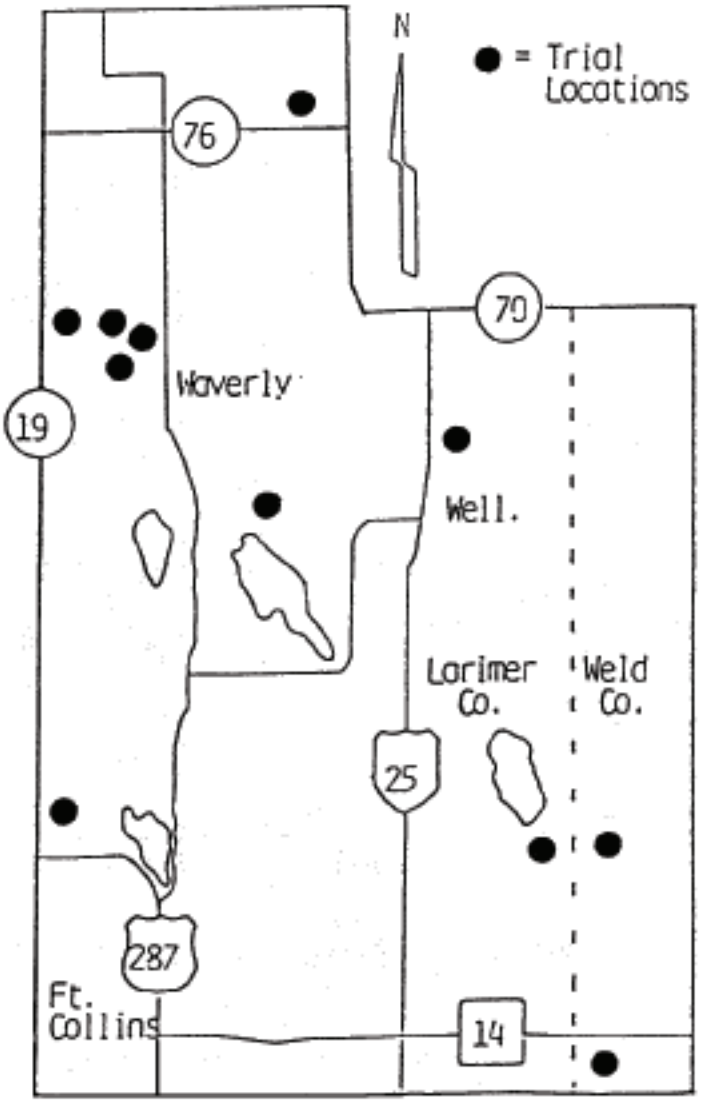

Figure 2. Map of the target area and trial locations.

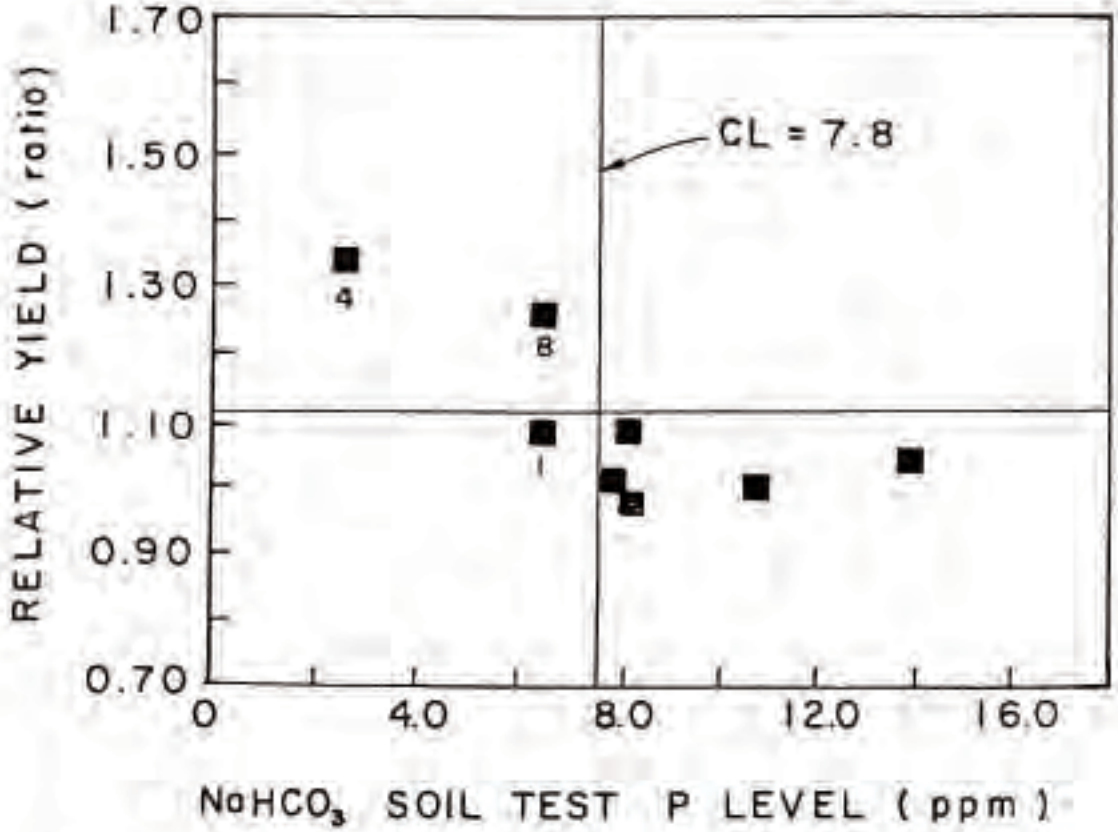

Figure 3. Determination of the critical soil test phosphorus level (CL) using the graphical method (Nelson and Anderson, 1977) for total season growth, 1985 data; Relative yield of the control = 1.00. Numbers refer to trial in Table 2.

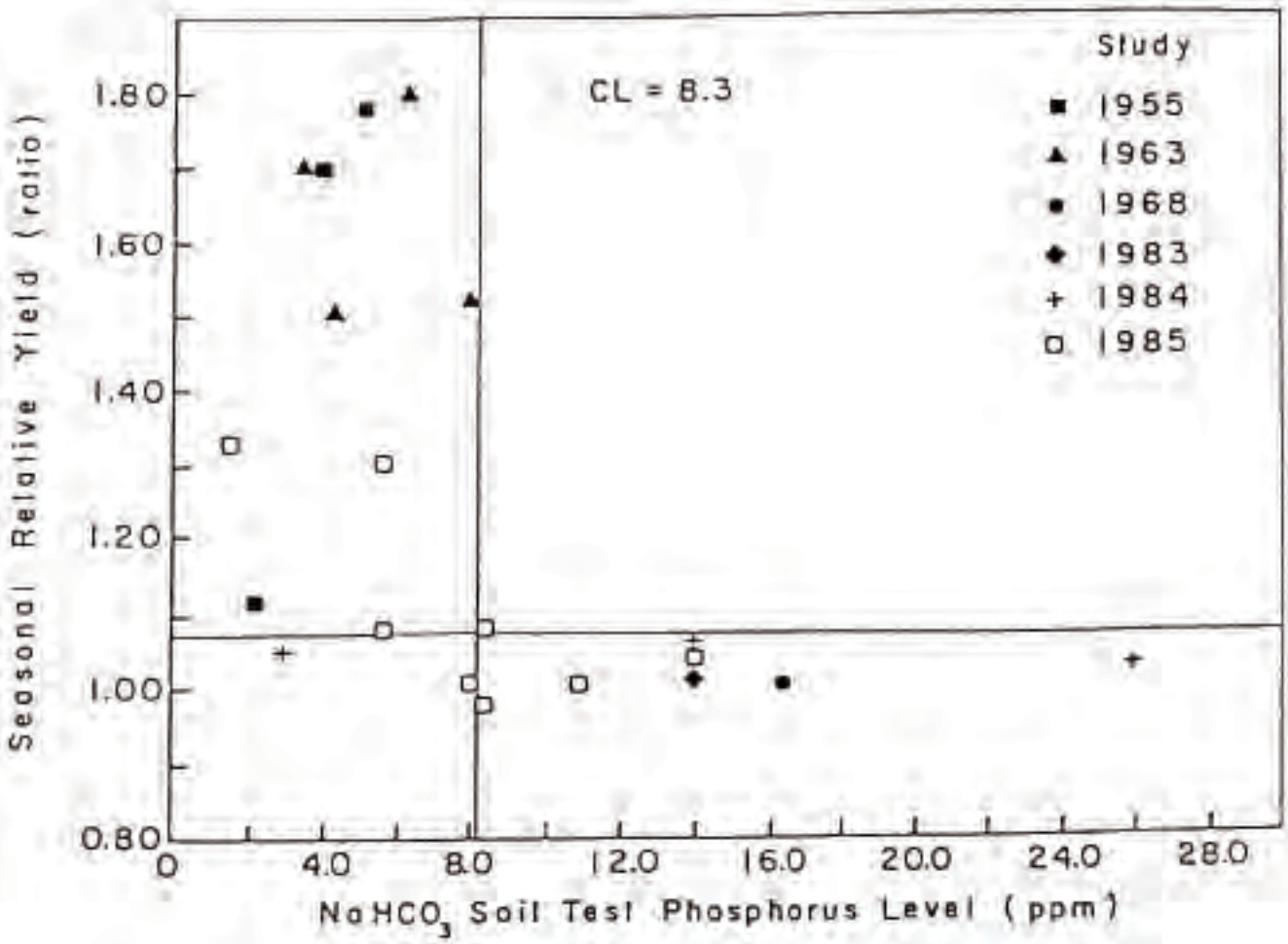

Figure 4. Critical soil test level for six phosphorus fertility studies (20 locations) on irrigated alfalfa in Colorado from 1955-1985.

COMPLEMENTARY NATURE OF CROP-ANIMAL RESEARCH

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INTRODUCTION

Most of the world's food supply is produced on farms where both crops and animals are present and production fits into a complementary system (Ruthenberg, 1980; Mares, 1983).

Farming system research programs are most effective when they include all components of a production system. Traditionally scientists have been organized into divisions based on common interests in plant or animal, specie and discipline. These groupings have certain advantages, particularly for component research, however they do not stimulate or facilitate systems type research. To further complicate cooperative research it is common to find not only the departmental barrier in the United States but separate research institutes in many other countries. Where animal institutes are separated physically and administratively from plant institutes it becomes very difficult to do cooperative research. Frequently a degree of competition exists for funding and recognition making it highly unlikely that cooperative research will occur. This is an unfortunate situation since forage produced by plant scientists must be converted through animals produced by animal scientists. It is obvious that joint research programs of a systems nature would be desirable.

Genetic engineering is being used to improve crop yields through better growth and resistance to insects, diseases and weather. Genetic manipulations that produce alterations in forage and grain quality may provide developing countries the opportunity to improve both crop and animal production at the same time. As both crops and livestock are improved on a localized basis it is important that these genetic changes be coordinated. As plant geneticists by breeding and selection improve quantity and quality of grain and/or forage produced Animal Science should also be adapting animals and systems of production to best utilize these materials.

The quality of the forage component has frequently been ignored when grain production was the primary objective. Research at Nebraska has shown that forage quality of corn and grain sorghum plants can vary significantly between varieties or strains with comparable grain yield. These differences have been demonstrated in grazing trials and with harvested crop residues. Although crop residue such as straw and stems of corn or grain sorghum are of low quality following grain harvest, they can be improved by chemical treatment with hydroxides or ammonia.

Agronomists at Nebraska have developed a new variety of switchgrass (Panicum virgatum) which produced 67 kg more beef/ha than a common variety. It appears that many forage crops could be significantly improved through breeding and selection for increased animal performance.

As population increases throughout the world arable land will be lost to developing cities and services. This will likely bring the more available grazing lands into the arable classification with marginal land converted to cropping. In order to maintain or increase the availability of high-quality

protein for human consumption, it will be necessary to intensify and improve animal production systems.

The objective of this paper is to emphasize the need for cooperative plant-animal research and to suggest ways in which it could be accomplished.

NEED FOR COOPERATIVE PLANT-ANIMAL RESEARCH

Since forages tend to have greater diversity in quality than grain, it is important for the plant and animal disciplines to develop joint research to improve their nutritive value. Research in grain crop production has centered largely on increasing grain yield with modification of grain quality characteristics sometimes a factor. These are appropriate objectives, however, with approximately equal amounts of grain and forage produced by crop plants such as corn, wheat and grain sorghum it is equally important that we also consider the quality of the forage produced. In most sections of the world the forage residue left after grain harvest is used for maintenance and production of ruminant animals. Mature ruminants require about 45% digestibility in forages to maintain body weight. Increasing digestibility would provide sufficient energy to allow for significant levels of growth, production or work. The level of productivity of these animals used for work, milk and meat is directly related to the quality of crop residues available. Although it is important to maximize grain production it may be equally important to enhance animal productivity. Milk and meat can provide nutrients frequently deficient in human diets consisting largely of grain and grain products. Since the feeding of grain crop residues provides only limited animal production above maintenance, a goal should be to improve crop residue quality to the point that it can be used by the animal for production.

Many developing countries have as a primary goal the increased availability of animal products for human consumption. Their achievement of this goal is difficult or impossible since they have little or no grain available for livestock feeding and since all available arable land is being used for grain production for human dietary needs. In order for livestock to be more productive they must be fed more energy such as grain or higher digestibility forage in the form of pasture, silage, hay or crop residue with improved digestibility. Research has shown that forage quality can be improved through breeding and selection without decreasing grain yields (Ward et al., 1986). Although the temptation exists to produce or buy additional grain for livestock feeding it appears that a more realistic goal should be to combine grain utilization with increased forage quality to improve animal productivity and enhance human diets. Development of improved forage quality crop varieties is a slow but relatively inexpensive process that will have long-lasting effects on the livestock industry of the countries involved. On the other hand grain feeding is expensive and must be repeated with every livestock cycle.

Grain yields will continue to increase due to improvement of varieties, fertilization, irrigation, disease and insect control. Crop residue will increase in approximately the same proportions as grain. The opportunity exists for plant and animal researchers to select for increased yields and forage digestibility and thus increase both quantity and quality available for feeding to ruminants. Work reported by Roth et al., 1986, indicates that corn varieties vary as much as 10-15% in digestibility and show significant differences in cattle performance when grazing or being fed residue. If corn yield could be increased 25% and residue quality 10% the quantity of digestible residue would be increased by about 37%.

Cooperative research efforts are now underway to determine the nutritive value of grass varieties as they are selected and improved. These efforts have great potential to increase animal productivity from either pasture grazing or crop residue utilization.

FORAGE QUALITY IMPROVEMENT

Switchgrass (Panicum virgatum)

Natural evolution of plants involves their ability to survive drought, insects, trampling and consumption of forage and seeds. In this process plant characteristics may evolve that are not conducive to the production of higher quality forage. The composition of stiff and erect stems with high cell wall (CW) and lignifications develop to support seed production and tends to reduce animal consumption. Breeding and/or selection for higher forage digestibility may be the most promising method of increasing animal productivity through improved nutrition. Development of a new variety of Switchgrass (Trailblazer) through divergent selection at the University of Nebraska Agricultural Research Center at Mead, Nebraska, has been shown to increase gain of yearling beef type steers by 67 kg/ha (Table 1) over a commonly used variety (Pathfinder). In vitro dry matter disappearance (IVDMD) of the top portion of the plant was higher ($P<.10$) than of the whole plant (Table 2). Although dry matter yield of the varieties was similar the digestibility difference of the readily available top portion of the plant increased productivity of beef cattle grazing the developed variety. In previously developed varieties the major emphasis had been on dry matter production with little or no consideration of quality parameters or animal performance.

Elephant (napier) Grass (Pennisteum purpurem)

Hassan et al., 1983, showed IVDMD differences of 17.2 units (70.0 to 87.2) between 23 varieties of napier grass. A study of plant characteristics of both erect and semi-erect varieties shows wide variability in chemical composition and fiber fractions suggesting that selection could greatly enhance the parameters studied.

Corn (Zea mays)

The improvement of corn grain yields and modification of plant characteristics through breeding and selection has been significant in recent decades. Forage composition may have been altered however little or no selection for increased quality as animal feed has occurred. Research at the University of Nebraska (Roth et al., 1987) shows wide variation in quality parameters of corn plant residues based on variety (Table 3). These differences are not highly correlated with grain or forage yields (Table 4). Based on animal performance trials where forage digestibility differences as low as 5-6% produced significant differences in animal performance we could assume this would also be true with different corn varieties. Animal performance data is now being collected. Fernandez and Klopfenstein. 1987, have shown that quality differences also exist due to climatological factors such as available moisture. Crude protein was higher and neutral detergent fiber lower in dry land corn residue than in irrigated (Table 5). These residue differences supported higher animal performance (Table 6). The opportunity for plant breeders and animal production researchers exists to improve animal productivity without sacrificing grain or forage productivity. Differences in dry matter digestibility of stalk and leaves due to variety exceed 25% which translate into significant animal productivity differences. The higher digestibility residues exceed animal maintenance requirements for

energy and therefore begin to have substantial net energy for production or gain potential.

Grain Sorghum [Sorghum bicolor (L) Moench]

Grain sorghum is produced in temperate regions of the world and used for both human and animal feeding. Residue quantity and quality vary greatly from country to country and also between varieties within country. These wide differences in characteristics suggest germ plasma variation useful in selecting forage of higher feeding value as crop residue. Cajal, 1983 reported differences in IVDMD of stem and leaf portions of grain sorghum residue due to variety. The higher stem digestibility variety supported higher (P<.01) animal gains (Table 7). Ward et. al., 1986, (unpublished data) found that calves fed residue from a grain sorghum composite selected for IVDMD had greater gains (.52 vs. .39 hg/head/day) than a commonly grown hybrid sorghum. IVDMD respectively for sorghum selected for high vs. low residue digestibility was 48.5 vs. 45.9". This data indicates that grain sorghum varieties can be selected to improve residue quality and improve animal performance.

Rice (Oryza sativa)

One of the most commonly produced crop residues is rice straw. The level of digestibility of rice straw has not been sufficient to maintain a mature ruminant. Fifteen varieties of rice were produced experimentally in the Philippines and tested for a number of quality parameters (FAO, 1983). Dry matter digestibility and organic matter digestibility ranged from 30.9 to 39.1 and 30.0 to 42.3 respectively (Table 8). These varietal differences exceed 30% from varieties where no selection for IVDMD has been practiced. It appears that significant changes in digestibility could be readily achieved resulting in better quality feed for livestock. A range of rice straw dry matter digestibility of 36-43 was reported by the Rice Research Institute, 1983.

Attempts to increase the utilization of paddy straw by adding urea and/or molasses, chemically treating, or grinding and pelleting have been somewhat successful but frequently not economically feasible (Krishna, 1982). Since much of the world's cattle and buffalo population are fed substantial amounts of rice straw it would be highly desirable to find ways to improve its forage nutritive value by plant breeding and selection. It would appear that sufficient genetic variation exists to provide that opportunity.

Wheat (Triticum aestivum)

Wheat is grown throughout the world under widely varied rainfall, temperature and soil conditions. These differences suggest not only varietal variation in straw composition but alterations due to climatological factors. Acock, 1978, tested 12 varieties of hard red winter wheat grown in Nebraska and found wide ranges in crude protein, IVDMD and ash (Table 9). Kernan et al., 1979, analyzed six cultivars of wheat straw and observed significant differences in digestible organic matter (DOM) ranging from 34.1 to 39.4%. Ammoniation increased DOM as much as 10.1% with significant cultivar difference in response to ammonia treatment.

CHEMICAL TREATMENT OF FORAGES

Hydroxides

The use of sodium, calcium, ammonium and other hydroxides to increase energy availability in low quality forages is well documented (Klopfenstein, 1978: Ward, 1978), Hydroxide treatment solubilizes hemicellulose and increases hemicellulose digestion (Klopfenstein, 1978; Jackson, 1978). The effectiveness of this treatment on wheat straw for maintaining gestating cows is shown in work reported (Table 10) by Ward et. al, 1985. Although hydroxides are very effective in increasing the rate and extent of digestibility the danger associated with their use and the detrimental effects sodium has in the environment have limited their use in animal feeds.

Anhydrous Ammonia

Anhydrous ammonia acts in a similar manner on low quality forages as do the previously mentioned hydroxides. Although it also is potentially dangerous to use it is commonly found on American farms and used as a nitrogen fertilizer. It has the added advantage of adding nitrogen to the feedstuff. Ammonia treatment can be applied to forages with moisture content of about 10% or higher; however, the treated material must be covered with plastic to prevent the escape of the ammonia gas. Ward et al., 1982, demonstrated the effectiveness of ammonium treatment of wheat straw (Table 11).

The use of ammonia on hay has been less successful (Table 12) and is generally not recommended. Low quality grass hay can be improved somewhat; however, it is not likely to be an economically justifiable process.

Some reports have indicated that the use of ammonia on grain sorghum residue or other higher moisture and higher quality residues can cause toxicity in cattle (Weiss et. al., 1986).

DISCUSSION

As world population increases, the demand for food also increases. Hrabovszky, 1981, predicted a world population of 6.2 billion by the year 2000. This calls for a 3.6% annual increase in crops and based on predicted demand for animal products a 4.7% annual increase in livestock production. If these production goals are to be realized, then it becomes imperative for the plant and animal disciplines to increase cooperative and complementary research. Since the potential for herd expansion is limited in most countries output per animal must be increased. This could be achieved with higher levels of grain feeding; however, grain may be needed as an energy source in the human diet. The logical conclusion is that we must increase forage availability and/or nutritive value. Since additional grain will be needed it appears that increases in forage supply will be primarily in the form of crop residues. We have the technology and genetic variation available to increase the energy available from crop residues by at least 10-15%. A significant portion of animal products needed by the year 2000 could be produced through an intensive effort to improve the quality of crop residues. Although it is likely that the proportion of poultry in diets will increase, the tonnage of beef needed by the year 2000 will exceed the 1986 supply. With about 71% (Mares, 1983) of the world's farmers producing both crops and animals, emphasis should be placed on farming systems research designed to improve both aspects of production simultaneously.

The improvement of grass varieties in terms of animal productivity should be continued and could add substantially to animal production. Plant materials from around the world should be studied for breeding purposes and aspects of Bio-engineering utilized in the breeding process. Intensive research and application could provide for the projected animal product needs of the world in the year 2000.

SUMMARY

The potential for complementary crop-animal research from the standpoint of increasing animal productivity through forage improvement is great. Grain production increase usually means an increase in the quantity of crop residue produced. Data show that residue digestibility can be increased by divergent selection based on IVDMD with animal performance trials to measure production improvement. Development of new varieties with higher nutritive value in the forage or residue may be the best method available to increase animal production. These objectives can be achieved only through cooperative research by disciplines, departments and institutes involving animal and plant science.

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Table 1. Steer average daily gain (ADG) and gain/ha on switchgrass strains[a].

Variety	ADG	Gain/ha
	----------kg----------	
Trailblazer	.73[b]	356[b]
Pathfinder	.53[c]	289[c]
Low-IVDMD	.64[c]	303[c]

[a] Anderson et al., 1984.
[b,c]Means within a column with different superscripts differ (P<.05).

Table 2. Top and whole plant in vitro dry matter disappearance 9IVDMD) for switch grass strains (dry matter basis)[a].

Variety	IVDMD	
	Tops	Whole plant
	----------%----------	
Trailblazer	66.6[b]	63.7[b]
Pathfinder	62.6[c]	62.0[b,c]
Low-IVDMD	62.8[c]	61.3[c]

[a]Ward, 1985.

[b,c]Means within column with different superscripts differ. (P<.10).

Table 3. Forage quality of stalk, husk, and cob representing 30 corn varieties, 1982 and 1984[a].

	Plant fraction								
	Stalk			Husk			Cob		
Variety	NDF[b]	DMD[cd]	NDFD[e]	NDF[b]	DMD[c]	NDFD[e]	ND[Fb]	DMD[cf]	NDFD[e]
1	76.7	50.9	45.3	87.4	67.3	66.0	89.8	43.1	41.1
2	68.7	63.3	32.5	74.3	67.3	57.1	98.9	32.1	30.3
3	59.8	62.0	40.3	73.4	62.7	57.3	86.9	43.1	44.5
4	73.9	56.0	45.0	83.5	66.3	63.7	89.2	39.8	35.0
5	65.5	62.5	57.3	78.6	72.0	67.2	91.3	32.3	24.7
6	68.0	61.6	49.6	69.8	68.9	64.1	86.5	46.5	42.6
7	68.5	61.9	51.8	78.7	72.0	68.2	87.9	46.1	40.7
8	76.6	55.4	48.7	86.8	69.5	68.7	92.0	37.3	34.6
9	70.9	59.9	55.6	80.2	68.6	66.2	88.5	44.3	42.9
10	70.8	57.1	45.4	84.5	69.9	68.0	88.5	40.8	35.8
11	60.7	59.9	43.5	81.7	65.8	64.2	87.2	40.0	40.6
12	72.5	56.6	48.2	83.0	66.3	62.2	88.6	43.0	39.2
13	79.3	53.0	45.4	84.5	64.9	63.0	92.6	36.1	32.4
14	66.3	59.2	47.8	82.3	72.5	70.1	88.0	40.0	36.0
15	70.9	57.1	49.4	85.1	67.2	63.6	91.2	35.7	32.2
16	69.3	56.0	45.9	83.8	68.2	64.9	89.9	39.6	36.3
17	75.6	52.0	47.8	85.6	70.4	68.1	91.5	40.6	37.9
18	74.4	56.1	47.0	83.7	69.2	66.2	90.3	39.9	37.4
19	77.2	53.0	49.4	87.1	68.9	67.6	90.7	36.1	31.3
20	76.9	51.0	44.2	86.6	70.8	69.1	91.0	40.2	39.7
21	77.7	51.9	46.1	84.3	70.8	69.2	91.9	41.5	38.9
22	68.5	56.5	48.3	82.0	64.5	60.9	92.0	38.1	31.1
23	78.9	48.2	40.2	87.6	66.8	65.1	92.4	37.7	34.6
24	59.6	52.7	37.3	84.9	65.9	67.4	88.3	39.4	35.9
25	78.7	55.2	47.5	89.0	68.1	67.0	90.6	39.1	34.1
26	68.2	54.7	48.4	80.2	73.2	68.8	86.2	41.8	42.2
27	75.8	50.6	44.9	86.7	69.4	67.6	94.1	37.6	31.9
28	66.8	62.4	61.0	81.9	71.6	69.0	87.1	41.6	38.9
29	63.1	60.7	44.8	82.7	60.3	57.7	88.7	35.9	26.8
30	75.9	51.2	45.2	85.7	68.4	64.7	90.1	39.2	37.1
Year									
1982		53.6						42.4	
1984		58.9						36.8	

[a]Roth, et al., 1987.
[b]Neutral detergent fiber, 1984.
[c]In vitro dry matter disappearance, 1982 and 1984.
[d]A difference of 7.5% indicates a difference between two varieties.
[e]In vitro neutral detergent fiber disappearance, 1984.
[f]A difference of 6.6% indicates a difference between two varieties.

Table 4. Grain, stalk husk and cob yield of 30 corn varieties, average of 1982 and 1984[a].

Variety	Plant fraction			
	Grain ton/ha[b]	Stalk ton/ha[c]	Husk ton/ha[d]	Cob ton/ha[e]
1	11.57	5.70	.94	1.62
2	11.32	6.67	.63	1.44
3	8.62	5.14	.63	1.39
4	9.31	5.26	.72	1.48
5	11.76	4.63	.74	1.08
6	11.32	5.70	1.01	1.48
7	9.81	5.08	.65	1.44
8	11.64	5.12	.85	1.50
9	11.89	6.20	.63	1.62
10	11.95	5.23	1.68	1.37
11	12.39	4.96	.88	1.55
12	11.95	5.01	.85	1.55
13	10.06	5.21	.99	1.28
14	11.20	4.76	.85	1.44
15	12.96	5.39	.88	1.46
16	12.52	6.24	1.08	1.82
17	12.96	5.16	.85	1.84
18	11.95	4.72	.94	1.30
19	11.51	5.30	.92	1.64
20	11.07	5.39	.96	1.62
21	10.94	5.30	.92	1.46
22	12.71	5.46	1.19	1.91
23	12.58	5.14	.94	1.68
24	11.32	4.99	.85	1.50
25	11.20	5.39	.92	1.64
26	10.94	5.82	.76	1.59
27	11.82	4.29	1.19	1.50
28	12.77	5.68	1.24	1.84
29	11.95	5.34	1.03	1.91
30	12.14	5.34	.96	1.50
Year				
1982	9.37	3.88	.70	1.19
1984	13.65	6.72	1.14	1.91

[a]Roth, et al., 1987.
[b]Contains 15% moisture. A difference of 2.14 ton/ha indicates a difference between two varieties.
[c]A difference of 1.44 ton/ha indicates a difference between two varieties.
[d]A difference of .40 ton/ha indicates a difference between two varieties.
[e]A difference of .54 ton/ha indicates a difference between two varieties.

Table 5. Crude protein (CP). Neutral detergent fiber (NDF) and in vitro Dry matter digestibility Dry matter digestibility (IVDMD) of dry land and irrigated cornstalks[a].

	CP[cd]	NDF[c]	IVDMD[d]
	- - - - - - - - - - - - - - - - -% of DM	- -	
Dry land cornstalks[b]			
Before grazing	7.5	80.2	45.6
After grazing	5.7	80.0	43.7
Irrigated cornstalks[b]			
Before grazing	5.6	84.2	45.2
After grazing	4.8	81.9	40.8

[a]Fernandez and Klopfenstein, 1987
[b]Cornstalks were grazed during 54 days.
[c]dry land vs irrigated (P<.05).
[d]Effect of time of grazing (P<.05)

Table 6. Daily grain of claves grazing irrigated and dry land cornstalks at one or two stocking rates[a].

Period (Days)	Irrigated 2.5 hd/ha	Dryland 2.5 hd/ha	Dryland 1.25 hd/ha
	- - - - - - - - - - - - - - - - - -	kg -	
0 – 28[b]	0.43	0.70	0.80
0 – 54[c]	0.42	0.60	0.60

[a]Fernandez and Klopfenstein, 1987.
[b]Irrigated vs dry land (P≤ .05)
[c]Irrigated vs dryland (P≤ .07).

Table 7. Calf average daily gain A(ADG)[a].

Variety	ADG (28 days)	ADG (56 days)
	- - - - - - - - - - - - - - - - kg	- - - - - - - - - - - - - - - - -
	0.50	0.25[b]
DK-59	0.58	0.44[c]
SE	0.10	0.09
CV	47.72	46.68

[a]Cajal, 1983.
[b,c]Means within columns with different superscripts differ (P<.01).

Table 8. In vitro dry matter digestibilities (DMD) and organic matter (OMD) of rice varieties[a].

Variety	DMD	OMD
IR 5	38.17	38.36
IR 20	33.11	31.07
IR 24	35.64	36.26
IR 28	39.08	40.26
IR 30	36.11	36.94
IR 32	38.98	42.28
IR 36	34.12	34.94
IR 38	30.92	30.90
IR 40	31.40	29.95
IR 50	37.08	37.76
IR 52	35.97	33.56

[a]FAO/UNDP/RP. 1983.

Table 9. Effect of variety and location on wheat straw characteristics[a].

	Crude protein	IVDMDb	Ash
	(%)	(%)	(%)
Range in 12 varieties	2.1-6.2	33.9-48.1	8.5-14.3
Range by location in Nebraska			
East	3.7-6.2	40.4-48.1	8.5-9.9
Central	3.8-4.5	33.9-42.3	11.0-14.1
West	2.1-5.4	34.1-47.5	10.1-14.3

[a]Acock, 1978.
[b]In vitro dry matter disappearance.

Table 10. Performance of cows in dry lot trials[a].

Treatment	Dry lot trial 1 1976-77		Dry lot trial 2 1977-78	
	Daily DM intake	Avg. daily[c] gain	Daily DM intake	Avg. daily[c] gain
	kg			
1. 1/3 alfalfa, 2/3 bromegrass[b]	8.2	.30[d]	8.2	.20[d]
2. 1/3 alfalfa, 2/3 wheat straw	11.8	.27[d]	10.9	.11[d]
3. 1/3 alfalfa, 2/3 NaOH treated wheat straw	10.0	.34[d]	12.4	.15[d]
4. NaOH treated wheat straw, SBM +minerals	9.9	.17[e]	12.2	.09[e]

[a]Acock et al., 1979.
[b]Limit fed.
[c]105 days.
[d,e]Unkike superscripts in a column differ significantly (P<.05)

Table 11. Effect of ammonization of wheat straw on beef cow intake performace[a].

	Treatments		
	1 Straw[b] + alfalfa	2 NH_3Straw + alfalfa	3 NH_3 Straw
	kg		
Trial 1			
Daily straw intake	8.8[c]	10.5[d]	----
Daily weight change	.12[c]	.40[d]	----
Trial 2			
Daily straw intake	6.7[c]	9.0[d]	11.9[d]
Daily weight change	-.12[c]	.18[d]	.05[e]

[a]Ward, et al., 1982.
[b]Straw ad libitum, alfalfa 3.2 daily to meet NRC protein requirement.
[c,d,e]Figures in a row with different superscripts differ (P<.01)

Table 12. Average daily gain (ADG) and dry matter intake (DMI) of cows on warm-season grass hay[a].

Treatment	1984-1985[b]	
	ADG	DMI
	kg	
Switchgrass	.70[d]	10.5
Ammoniated switchgrass	.85[e]	11.1
Big bluestem	.75[f]	10.4
Ammoniated big bluestem	.87[g]	11.5

[a]Ward, 1985.
[b]Switchgrass trial duration = November 6 to January 10 (65 days). Big Bluestem trial duration – November 6 to January 15 (70 days).
[d,e]Means within column differ at (P<.18) level.
[f,g]Means within column differ at (P<.01) level.

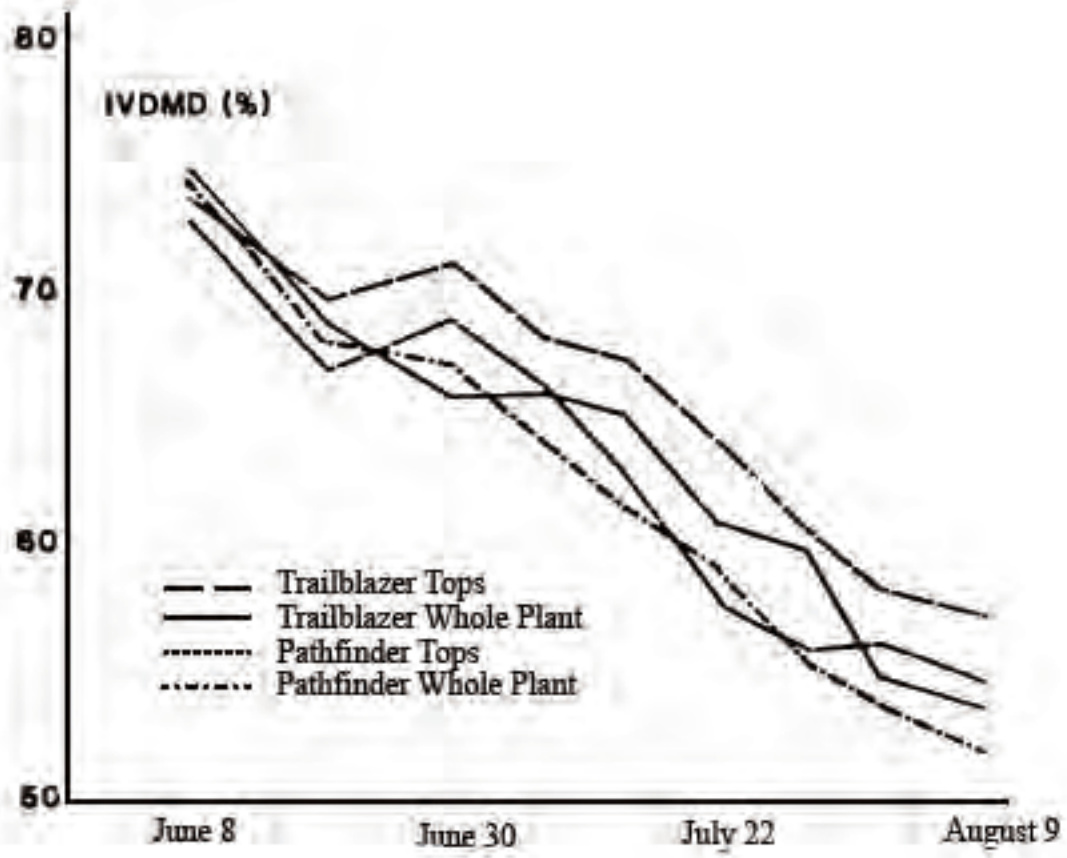

Figure 1. Top and whole plant in vitro dry matter disappearance (IVDMD) for Trailblazer and Pathfinder Switchgrass during 1983 grazing season.

INTEGRATIVE STRATEGIES OF LABOR ORGANIZATION FOR CROP-LIVESTOCK PRODUCTION IN AN INDIGENOUS ANDEAN COMMUNITY

Constance M. McCorkle

This paper describes and analyzes the socio-organizational dialectics of agropastoralism among Quechua Indians of highland Peru, based on anthropological field work for the Small Ruminant Collaborative Research Support Program (SR-CRSP) in 1980. The focus here is upon how peasants solve the problem of recruiting daily labor for supervision of range stock while at the same time pursuing preindustrial, or paleotechnic, agriculture -- i.e. cropping which is primarily dependent upon human and animal energy and a simple, non-mechanized tool culture (Wolf 1966).

Both for the Andes and worldwide, the many advantages to combining cultivation and herding have been well-documented. However, in peasant economies the two production systems are difficult to integrate effectively. For a host of reasons linked ultimately to the limited productivity of a paleotechnic adaptation, they conflict with each other at many points — ecological, technological, and socio-organizational.

As Vincze (1980) has observed, given the peasant goal of productive autonomy, perfect integration is achieved when the household can provide for all its agricultural and pastoral needs. The latter include: sufficient and nutritionally balanced pasture and cultivated fodder to see animals through dry or winter seasons; adequate shelter from the elements and protection from predators and thieves; skilled veterinary care for docking, castrating, disease prevention and curing, birthing, etc.; and sufficient and competent labor for shearing, daily herding, and so forth.

However, this ideal presupposes an intensive agricultural adaptation capable of providing for fodder cultivation, grain feeding, rational pasture rotation systems (usually implying fencing), strong sanitary shelters, and herd divisions by sex, age, and species. Peasants can hardly aspire to this ideal. They typically suffer from a shortage of arable land (whether socio-politically or naturally imposed) which, coupled with a paleotechnology, leads to low agricultural productivity. In addition, conflict arises between human and animal needs in the allocation of scarce cultivable land. Peasants can seldom afford to plant much fodder or to divert much, if any, grain to animal feed.

Without intensive hay and/or grain feeding, animals cannot be permanently stabled. Instead they must forage for food on open ranges. Rangestock operation introduces further conflicts between agriculture and pastoralism by geographically divorcing the two. Pastures must be sought farther and farther afield as those near croplands become exhausted (Jamtgaard and McCorkle in progress, McCorkle in press). In consequence, workplaces become separated, sometimes by considerable distances. This leads to additional disjunctions, particularly in the allocation of labor.[1]

Indeed, the organizational problems of labor recruitment, allocation, and synchronization are among the most difficult facing peasant agropastoralists.

These problems are exacerbated by a generalized procurement strategy (Rhoades and Thompson 1975) in one of the world's most complex environments -- high-altitude tropical mountains. There, peasants must cope with multiple species of plants and animals and exceptional ecological variation in fields and pastures.

Given the range of crops to be tended at varying times in different and widely dispersed microniches, scheduling the intense manual labor demands of paleotechnic agriculture and, even more challenging, synchronizing these with the competing demands of pastoral ism, pose a serious threat to integration of the two types of production. This is especially true at peak labor crunches in the agricultural cycle, when animals may have to pasture far from the village and may require extra attention beyond the usual daily grazing. Moreover, different livestock species require different forages which may be located in dispersed eco-zones.

There is a further difficulty in the allocation of pastoral labor. This concerns the relatively small herds most peasants households can afford to keep. Given the lack of stabling or fencing, someone must be in everyday attendance upon the creatures. Yet when a single individual can easily oversee three or more households' herds, it seems a less-than-optimal utilization of labor to shift one family member from agricultural to pastoral work merely in order to supervise a few dozen animals.

This is particularly true given the norm of neolocal nuclear families and bilateral kinship among Andean agropastoralists. They do not enjoy the rich labor resources of permanent extended households or elaborate, lineage-like structures.[2] Nor do many communities boast formal pastoral organizations for aggregating herds and sharing out grazing and other pastoral duties.[3] Neither do they often have recourse to herding specialists.

In short, in mixed peasant economies, crops and livestock are in direct and, at certain times of the year, acute competition with one another for scarce household labor. Some organizational measures must be taken to offset this conflict. After a brief review of the research setting, the variety of herding strategies employed in one indigenous Andean community are described and socioeconomically analyzed. The concluding section suggests some of the implications of these findings for development efforts aimed at increasing either crop or livestock production in such mixed, peasant farming systems.

CROPPING AND HERDING IN USI

The study community, Usi, lies above the Vilcanota River valley in the District of Quiquijana, Province of Quispicanchis, Department of Cuzco, Peru (Figure 1). In 1980, its population consisted of 106 households averaging 5.6 members. The people are Quechua-speaking Indians whose culture and technology represent the most traditional to be found in highland Peru today (McCorkle 1983a). Politically, the village is organized as an official Peruvian Peasant Community.

Herding is an important enterprise in Usi. Sheep, llama, alpaca, and cattle are raised; 84% of all families keep at least one of these species. Within the 30% stratified village sample studied, mean family holdings at

the time of research were 26.8 ovines, 4.6 camelias (mostly llama), and 1.3 bovines. While these numbers seem small by Western standards, their importance for Andean peasants' survival is large -- not only for the cash, wool, hides, leather, meat, milk, cheese, and transport they provide but also for their invaluable manure. Without this critical animal product, potato cultivation in Usi would hardly be possible (ibid., Winterhaider et al. 1974).

The community occupies a "compressed" (Brush 1977) type of Andean vertical ecology (Murra 1968, 1972) roughly extending from 5000 m down to 3200 m at the Vilcanota valley floor (Figure 2). Within this altitudinal gradient, villagers exploit three major agrolife zones (Mayer 1979). Each manifests a different constellation of animal and plant crops, climate, land tenure, and peasant ecotype (Wolf 1966) or agricultural regime (Guillet 1981).

- The low, or maize, zone: 3200-3500 m. This is the warmest and most fertile area. It is primarily devoted to fenced, privatized, irrigated maize fields which are cropped yearly. But potatoes, field peas, squashes, wheat, ulluku (Ullucus tuberosus), kinwa (Chenopodium quinoa), and a few fruit trees are also raised. In parts of this zone, the Spanish plow can be used. Because the land is under near-constant cultivation, little herding is done except for postharvest stubble grazing or pasturing a few head of cattle, since this species thrives best at lower altitudes.

- The intermediate, or tuber, zone: 3500-4000 m. The main population settlement is located in this zone, the better to exploit the other two. Rainfall cultivation with the Andean foot plow is the rule here. Potatoes and other tubers are the principal crops, alternating with barley; but broadbeans and Andean chenopods and lupines are also raised. The land is operated under the Andean sectoral fallow system (Custred and Orlove 1974, Mayer and Fonseca 1979) with sectors being cultivated for two years, and then fallowed for three years while also serving as communal grazing grounds. Sheep are the predominant herd animal here.

- The high, or pasture, zone: 4000 m and above. Here lie the high, cold punas of the southern Andes, where the native bunch grasses dominate the landscape. Aside from some limited cultivation of bitter potatoes and barley, this area is given over to communal pasturage year round. All ruminant species can be grazed here, although at these extreme altitudes cattle reportedly fare poorly while the indigenous camelids thrive best. Sheep are said to produce better here, too.

Figure 3 graphically illustrates Usi's complex agricultural cycle. (For additional details, see McCorkle 1983a:45 ff.) Clearly villagers must deal with many kinds of plants, fields, seasons, and even differing agricultural implements and techniques. The number of crops to be tended is nearly doubled since there is both an early and a late or an irrigated and an unirrigated planting for many cultigens. Additionally, all major crops are grown in a gamut of subspecies; and the plowing, furrowing, fertilizing, planting,

seeding, hoeing, harvesting, threshing, preserving, and storing schedule varies for almost every crop. All these activities are performed with a paleotechnic tool kit. Moreover, the demands of cultivation are relatively inflexible. Land must be plowed while still soft from the rains. Ripening crops must be protected from theft and the depredations of animals. Fields must be harvested before the frosts come. And produce must be processed and stored before it spoils.

In sum, at no month in the year are Andean agropastoralists entirely free of the heavy manual labor of preindustrial agriculture. At the same time, under rangestock operation animals require daily droving and supervision -- not to mention other, aperiodic pastoral chores like shearing, breeding, docking, castration (Figure 4). Multiple-species management of rangestock across different agrolife zones intensifies the pastoral production schedule. Even a quick visual comparison of Figures 3 and 4 in the context of Figure 2 should suggest some of the spatial, seasonal, and production-system complexities confronting these Andean peasants' allocation of scarce human resources. How, then, does the nuclear household obtain and organize the daily labor to oversee its herds and herd subdivisions?

PASTORAL LABOR ORGANIZATION STRATEGIES IN USI[4]

To address this question, Usinos turn to small scale herding associations which rarely reach a cooperative level greater than three households. These associations may be kin-, fictive-kin, or non-kin-based. They comprise nuclear-family-external but community-internal relationships involving an assortment of labor exchange, procurement, and specialization devices. A single household often must have recourse to several such arrangements to meet its multiple-species herding needs. While males and females both can initiate pastoral associations, women, adolescents, and children are primarily responsible for daily herding.

The preferred form of pastoral labor organization in Usi is that known variously as cooperative, reciprocal, or exchange — in which labor is traded for labor. As Custred (1977a:73) notes this is the most rational mode of interfamilial cooperation in the Andes.[5] More rarely, villagers resort to contractual labor, defined as exchange of labor for the equivalent in cash or kind. But in fact, cash never directly figures in such transactions among Usinos. Instead, payments are made in varying combinations of goods, services, meals, and raw agricultural and pastoral products. Both forms of labor also entail diffuse social costs, e.g.: contributions to and attendance at herding partners' ceremonial celebrations; exchange of small gifts and friendly advice; assistance in agricultural, culinary, gathering, and other chores; lending tools or foodstuffs; and so forth.

Social costs in part relate to another feature of all these relationships-- their "unofficial" or dyadic-contract nature. Such associations are "...informal, or implicit, since they lack ritual or legal basis. They are not based on any idea of law, and they are unenforceable through authority; they exist only at the pleasure of the contractants" (Foster 1961:1174). Ancillary social exchanges reinforce these unenforceable relationships. Of course, mutually agreeable terms of exchange, a high degree of trust, and confidence in pastoral competencies are all necessary to the establishment and

stability of such associations. If one household often proves uncooperative or falls behind in its reciprocal obligations, or if herders become lax or dishonest in their task, the relationship will be terminated.

Usino herding associations vary in their duration and periodicity, depending on whether participants' needs are expected to be short term or long term, regular or irregular, and on whether households are in a position to return reciprocal labor. Families select among and initiate and terminate arrangements accordingly. Additional considerations in choosing herding associations and partners include, e.g.: the species involved; the physical and sociostructural distance between participants; relatedly, the social and material costs entailed; "extra" sources of income in the client household (e.g. from migrant wage labor or crafting); and lines of inheritance.

The following discussion of Usino pastoral labor organization is broadly organized in keeping with villagers' own preference for reciprocal over contractual labor. Hence the most common strategies are described first. This approach also produces a rough associational sequence moving from informal to more formal, and from generalized to balanced reciprocity.

Joint Herding

This simple strategy is almost universal in Usi. It merely consists of groups of herders grazing their animals together on the same day in the same locale, either by happenstance or design. The benefits of joint herding are both social and economic. Women may while away part of the long grazing day in conversation, reinforcing kin and friendship ties. Adolescents may do the same, while sharing a bit of flute music or teasing and flirting with the opposite sex. Child herders enjoy games and general play.

The economic advantage is that companions can keep an eye on each others' animals while taking turns at supplementary gathering activities – collecting firewood or dung for the cook stove; grasses and leaves for guinea-pig or cattle feed; straw for thatch and kindling; magical and medicinal herbs; and so forth. Joint herding thereby frees part of the pastoral day for other economic activities.

This strategy has other benefits, too. It is especially useful for households in the early stages of the domestic life cycle. Given their limited labor supply, they must sometimes send a five- or six-year-old out to herd. In such cases, parents usually arrange for the child to accompany a known and trusted older individual who is also herding that day. No fees or standardized exchanges are incurred in any instance of joint herding.

T'inkikuy

Although a precise translation is impossible, t'inkikuy connotes "offering aid"; but it denotes a reciprocal exchange of labor for daily supervision of herds. It is the equivalent in animal husbandry to Andean agriculture's ayni -- service performed in return for exactly the same service, figured on a per-day/per-person basis, and kept in strict accounts.

The logistics of this arrangement are simple. A member of one of the cooperating households collects the animals of the others in the morning. She/he then drives the aggregated herds out to pasture and watches over them

together. At the end of the day, the animals are returned to their home corrals. This association is most often used for sheep.

T'inkikuy agreements are reached by mutual and friendly consent between two or more households, almost always in the same neighborhood. The families may or may not be related by real or fictive kinship. Women typically initiate the association, but the full membership of each household -- men as well as children -- is implicated in the agreement, and their labor may be called upon to help meet it.

The understanding is that caretaker services are always "on tap"; but for aperiodic occasions, prior plans convenient to all concerned must be made. When the need for herding help is regular and predictable, a longstanding schedule of labor exchange may be instituted. Payment is always rendered in return service, not in cash or goods. However, when the herder is a non-adult, the family receiving the service must supply her/him with the customary cocabi, a cold lunch, for the day.

T'inkikuy is by far the most prevalent pastoral association in Usi. Nearly every stock owning household practices it at one time or another in the course of a year — e.g. during the harvest time labor crunch, when entire families sleep out in the fields to protect and gather their crops; or during the academic year when child labor for herding is at a premium. Without this socio-organizational resource few families would be able to raise livestock at all.

Species Specialization

In this association, two households possessing small numbers of different-species animals merge their same-species herds and divide the responsibility for their care. For example, the cattle of one household are cared for and quartered by another cattle-owning family, while the Tatter's sheep join the sheep of the former. This arrangement is typically kin-based and longterm, and involves no formal payments of any kind. Species specialization is a particularly apt labor-saving device in that it simultaneously aggregates animals and provides for important herd divisions which permit improved husbandry. Its advantages are several.

First, if the two households did not cooperate in this fashion, then twice as many herders ideally would be required in order to exploit the forages best suited to each species across dispersed agrolife zones. Second, only half as many corrals are required. Villagers note that, for a number of health and security reasons, large and small ruminants should be corralled separately. But these sturdy stone or adobe structures are in somewhat short supply in Usi. Third, this strategy doubtless allows some specialization of pastoral knowledge. A household dealing daily with only one species has greater opportunity to learn more about its forage preferences, idiosyncratic illnesses, social behavior, etc. and can therefore afford it better care.[6]

Boarding

Boarding offers an alternative organizational "out" for households who are short on labor yet, again, own two or more species of herd animals which ideally require different but dispersed forages. Boarding consists of placing animals at a co-villager's puna 'ranch' (estancia or astana) in the high agrolife zone. Most often, camelids are boarded long term at such ranches.

Temporarily, ailing or infertile camel ids may be boarded so they can take advantage of the better forages and reputedly more salubrious climate of the punas. Cattle and sheep may also be boarded during the harvest.

Boarding is a contractual association. Fees are fairly standardized. According to all informants, one q'ipirina (some 15 pounds) of avio (foodstuffs and supplies) must be delivered roughly once monthly to the ranch personnel. Also, members of families receiving longterm boarding services may occasionally take a turn herding at the ranch or helping repair its structures.

Ranch owners and non-owners both benefit from boarding associations. Even wealthy ranch owners appreciate the input of labor and goods from boarders, for it significantly defrays the material and human costs of maintaining an extra residence in the puna. And non-owners who lack the labor to range divided herds across different agrolife zones can thereby invest in greater numbers of different species. Also, by affording ailing or infertile camel ids the improved nutrition of puna forages, people can better protect their investment in this more costly species.

Recruitment of Child Labor

Under this rubric are grouped three organizational strategies which differ in their structure and payments, but which are related insofar as all concern recruitment of extra household child labor for daily herding. Quite simply, a labor-poor family solicits the use of a surplus boy or girl from another household. As Thomas (1973) argues, children are the preferred source of pastoral labor in the Andes because they are energetically the most efficient. The following associations help equalize the distribution of this valuable resource across the community. At the same time, they ease subsistence strains on households with more than the average number of mouths to feed.

Short term Rent-a-Child. This consists of outright hiring a child -- often from non-kin -- to do one's herding on a brief and aperiodic basis. Payments are made to the child's parents in small amounts of avio – one unkuna (about five pounds) of local foodstuffs for every two to three days of herding. Additionally, the child receives a daily lunch. Adolescent girls may also earn several handful s of wool for each day they herd.

Short term rent-a-child appears to be a "last ditch" method of acquiring pastoral labor in emergencies. As noted earlier, reciprocal is usually preferred to contractual labor (especially for overseeing the inexpensive ovine). However, when a family's normal network of kin, friends, and t'inkikuy partners fails them, they may hire a child elsewhere. They may do so because they are so labor-poor they cannot return t'inkikuy, or because they are unwilling to assume the increased social costs of initiating new reciprocal obligations. In such circumstances, short term rent-a-child may offer the most attractive solution to irregular, temporary labor problems despite its material outlays.

Long term Rent-a-Child. This strategy ensures a stable supply of pastoral labor when family shortages are apt to last for several years, e.g. at the beginning or end of the domestic life cycle. In long term rent-a-child the herds of two households are daily pooled, to be overseen by the child of one.

Formalized annual payments of stipulated items of clothing must be made to the child, along with the usual lunches. Additionally, it is informally understood that the client household will occasionally aid the herder's parents in various tasks.

Wardship. Wardship differs from all the other organizational strategies detailed here in that it responds to family labor shortages not by aggregating animals but by shifting labor from one household to another more or less permanently. I.e., a child from one family takes up residence with another, usually an elderly relatives'. Also, this association supplies labor for a host of chores other than just daily herding — fetching water from distant springs, processing and preparing food, carding and spinning, delivering messages, washing clothes, gathering fuel, feeding barnyard animals, and so on. Wardship is therefore an especially apt form of labor recruitment for elderly or infirm couples who require more help in more varied activities than other labor-poor families.

Parents retain ultimate authority over the child. No formal payments are stipulated, but it is understood that guardians will provide all the child's basic needs -- room, board, clothing, medical expenses, etc. There is also evidence that lines of inheritance play a role in this association. When "child givers" are unlikely to inherit from "child takers," the more formalized and balanced reciprocity of long term rent-a-child typically obtains. But if inheritance is a real possibility, wardship may result. Indeed, I suspect that child givers are willing to surrender essentially all the child's labor in wardship only if they estimate that the child takers will substantially recompense them and/or the child through future endowments such as an extra share of the funeral herd.

Absentee Caretaking

When stockowners are absent from the village for an extended period -- e.g. to do migrant wage labor or visit distant relatives — their animals may be left in the care of a kinsperson, or possibly a friend. Absentee caretaking is reimbursed in livestock. The precise numbers, age, and species of animals to be paid vary according to: the social distance between caretaker and client; the length of the client's absence; the size and composition of the herd being cared for; and the "heart" or good will of the animals' owners (McCorkle 1982, 1983a). These long term caretaker associations are important for both household and community economy. They free people to earn significant cash income in the national sector without foregoing the income or the social and investment benefits of pastoral ism.

Dar en Partir

Literally 'to give in sharing', this association apparently derives from the traditional Spanish institution of herding a medias or a mitades 'by halves'. It is a highly balanced, formal, and long term arrangement common throughout the Andes and many other parts of the world. An individual simply gives animals into another's care with the agreement that each will share equally in the herd's growth over time. In Usi, dar en partir almost invariably involves cattle. It provides caretakers an excellent opportunity to add to their holdings of the most valuable herd animal without any outlays in cash or kind. And the client family gains the same advantages described above for species specialization.

SUMMARY AND ANALYSIS

As Rhoades and Thompson (1975:539) have observed for the Himalayas, in the Andes, too, "Given the present level of...technology, there exists no single zone even potentially capable of supporting the entire population for any length of time." Usinos therefore endeavor to produce a mix of crops and animals in each of their agrolife zones. For the autarchical peasant household, however, this engenders serious disjunctions in the organization of production -- notably, in securing daily labor for overseeing their small but multiple-species herds across dispersed locales.

Usinos respond to this disintergrative challenge with a variety of smallscale suprahousehold associations apparently derived eclectically from both Incaic (e.g. t'inkikuy) and Spanish (e.g. dar en partir) tradition. Given their nuclear-family structure, without such strategies only the largest and most labor-rich families would otherwise be able to pursue pastoralism at all.

As noted, these associations offer many and varied benefits, not only in pastoralism per se but also in other economic and social spheres. By pooling herds, of course, they free more labor for agriculture and other activities. Herd aggregation also facilitates provision of specialized care and forages for different species. Relatedly, certain associations ease multiple-species pressure on household corral resources. Others distribute child labor for herding -- and with it, children's subsistence costs -- across households. At the same time, these associations may furnish elderly folks with much-needed general help and companionship, and allow younger families to start their pastoral portfolios. Moreover, certain arrangements permit individuals to initiate or increase their herds by "earning" livestock, while freeing others to earn cash.[7]

Added to the foregoing benefits is one further, overarching advantage to Usi's small scale associations: their intrinsic flexibility. Andean peasants' labor needs and resources typically vary markedly across the years due to the region's periodic droughts and animal epidemics, dramatic shifts in household composition across the domestic life cycle, and the natural increase and decrease of herds. Labor needs can also vary across a few months or weeks thanks to: the fluctuating demands of multi-crop agriculture in a tropical vertical ecology; the health and/or forage needs of different species, or even individual animals, at different altitudes and times of the year; family travel or crisis; loss of child labor when school is in session; and so forth.

By initiating and terminating relationships as necessary, stockowners avoid the mounting material and social costs of more formal, permanent arrangements. This flexibility and relative informality allow villagers to respond rapidly and rationally to their highly changeable physical and social environment.

IMPLICATIONS FOR DEVELOPMENT

The labor organizations described above give testimony to the dialectical nature of paleotechnic agropastoralism. Because cropping and herding stand in an at-once complementary and competing relationship in mixed peasant farming

systems, development projects aimed at enhancing either of the two types of production can ignore the other only at the risk of "robbing Peter to pay Paul."

I.e., to the extent that basic resources like land and labor are diverted from one sector in order to develop the other, peasant subsistence will be imperiled. The margin for error and experiment in such farming systems is small; many families live at the very edge of survival. Development programs calling for significant inputs of additional labor from the already harried peasant household are therefore unlikely to meet with much success unless there are appropriate accompanying changes in the social organization of production.

Drawing upon these Andean data, let us pose a hypothetical set of livestock development goals -- e.g. improved husbandry techniques like quarantine of diseased animals, refined herd subdivisions for specialized care and feeding, or explicit systems of pasture rotation -- none of which are practiced in Usi. Under range stock operation in a paleotechnic adaptation, however, these familiar management methods characteristic of more intensive technologies will likely run squarely into the problem of acute household labor shortages for such pastoral niceties.

The solution lies in the organization of labor itself. Although the small scale associations described here do lighten the load of pastoral labor upon the production unit, they hardly approach Vincze's (1980) ideal of minimizing the conflicts between pre industrial cropping and herding while maximizing their complementarities. Ceteris paribus, in the realm of pastoral labor this "miximax" ideal is better dealt with through large scale organizations which aggregate many households' animals and thereby release a maximum amount of labor from daily herding (ibid.). To achieve such aggregation, development programs can (and should) take their cue from indigenous socio-organizational resources.

For example, with regard to isolating diseased animals or dividing herds by sex, age, species, function, etc., such units could be aggregated across many households and the labor for overseeing them apportioned in t'inkikiy or species-specialization fashion. Likewise, transfer of both the metaphor and the reality of strategies like t'inkikuy or joint herding from the interfamilial to the moiety or community level could facilitate both communication and introduction of pasture rotation systems.[8]

A dialectical and socio-structurally sensitive approach tackles development within the context of the farming system and community as a whole. Gains in one area and type of production will therefore redound to the benefit of the other. For example, increased organization of pastoral labor should free up a "bonus" of labor for agriculture. And utilization of indigenous socioeconomic structures will naturally cause less disruption of traditional culture than introduction of alien organizational models. The admonition here is simple. First, the means for attaining project goals must be carefully assessed vis a-vis both the integrative and disintegrative aspects of peasant agropastoralism. Second, work <u>with</u> rather than <u>against</u> or perhaps even <u>for</u> the indigenous system.

Of course, this is possible only to the extent that systemic features-- ecological, technological, socio-organizational, etc. — have been empirically verified for the target community and their place and functioning within the total farming system fully comprehended. This prior task is best assumed by a closely coordinated interdisciplinary team pooling their expertise. With such careful groundwork, it is possible to predict the pitfalls and potentials for development initiatives in peasants' complex crop and livestock production systems.

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NOTES

[1]Elsewhere I have discussed dialectical tensions for techno environmental and veterinary health issues (McCorkle 1873b and 1982, respectively).

[2]The problems facing Andean agropastoralists are highlighted by comparison with "pure" pastoralists of the region. The latter typically inhabit only one altitudinal zone and live in permanent extended families and/or durable, cooperating patrilineages (cf. Custred 1977b, Flores 1977, Inamura 1981, Orlove 1977, and Palacios 1977). Furthermore, they may herd only two closely related species (llama and alpaca) and cultivate little more than a few varieties of bitter potato.

[3]Like the various alp associations of traditional Swiss peasants (Friedl 1974, Netting 1976), the Galician beceira or ronda (Reiner Bauer pers. com.), or the paliskunta of Finnish reindeer owners (Ingold 1983).

[4]Whenever possible, I label each association with the term (whether Spanish or Quechua) most often employed among Usines themselves. Where no such term was discovered, I coin my own.

[5]See Guillet 1980 for a thorough-going explanation of the constellation of cost-benefit ratios behind reciprocal labor and why this is more efficient for the Andean peasant than hiring wage labor.

[6]This is an especially important consideration for cattle-owners. Less than 50% of Usino households possess cattle. Consequently, relatively few people have extensive knowledge of their needs and habits. Moreover, like sheep, cattle are imperfectly adapted to the harsh Andean environment and peasant husbandry system. Yet they are the costliest of herd animals. Specialization of labor in and separation of bovines may therefore constitute a highly rational means of protecting this major, but risky, investment.

[7]However, one disadvantage to certain of these associations (e.g. boarding, rent-a-child) is that insofar as agricultural products slated for human subsistence must be paid out to support pastoral ism, there is again competition between the two production systems. In contrast, associations like absentee caretaking and dar en partir -- in which animals are exchanged for animal care -- create no such tensions.

[8]Of course, in the Usino case described here, other issues would remain to be dealt with. For example, juridical mechanisms to control incompetent or dishonest overseers would have to be instituted (cf. McCorkle 1982, 1983a). And the flexibility characterizing present pastoral labor strategies would need to be built into any larger-scale associations.

ACKNOWLEDGEMENT

My thanks to Michèle Lipner for her many helpful comments.

FIGURE 1

LOCATION MAP OF USI*

MACHU PICCHU
CALCA
PAUCARTAMBO
CUSCO
CUZCO
URCOS
PARURO
QUIQUIJANA
Usi
ACOMAYO
YANAOCA
SICUANI
SANTO TOMAS
YAURI
AYAVIRI
BOLIVIA
PUNO
JULIACA
To AREQUIPA and LIMA
PUNO

LEGEND

- DEPARTMENT CAPITAL
- PROVINCIAL CAPITAL
- DISTRICT CAPITAL
- Communities, Haceandas, Anexos

- DEPARTMENTAL BOUNDARY
- NATIONAL BOUNDARY
- PAVED ROAD
- EARTH ROAD
- RAILROAD

0 25 50
KILOMETERS

FIGURE 2

THE VERTICAL ECOLOGY OF USI

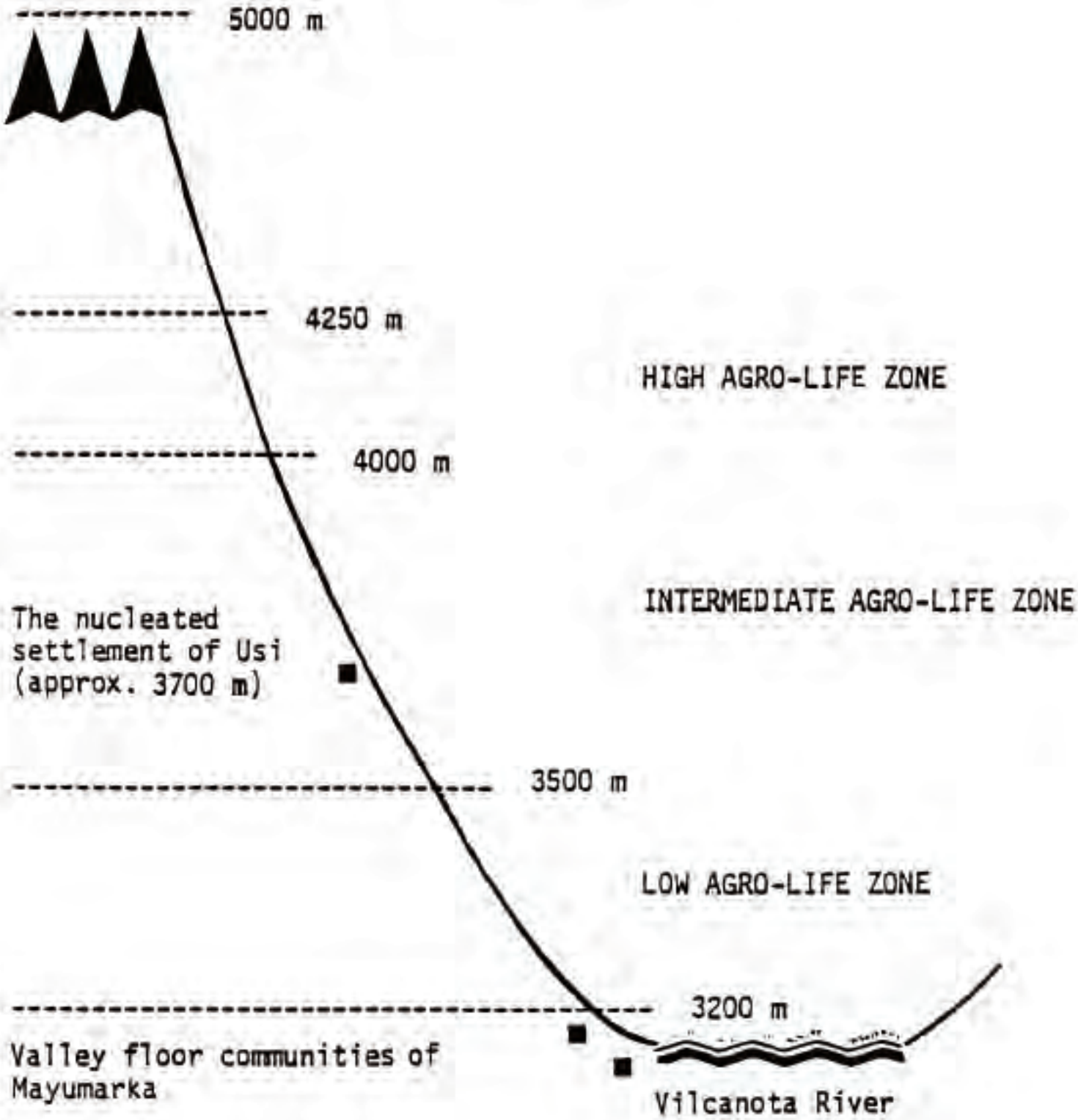
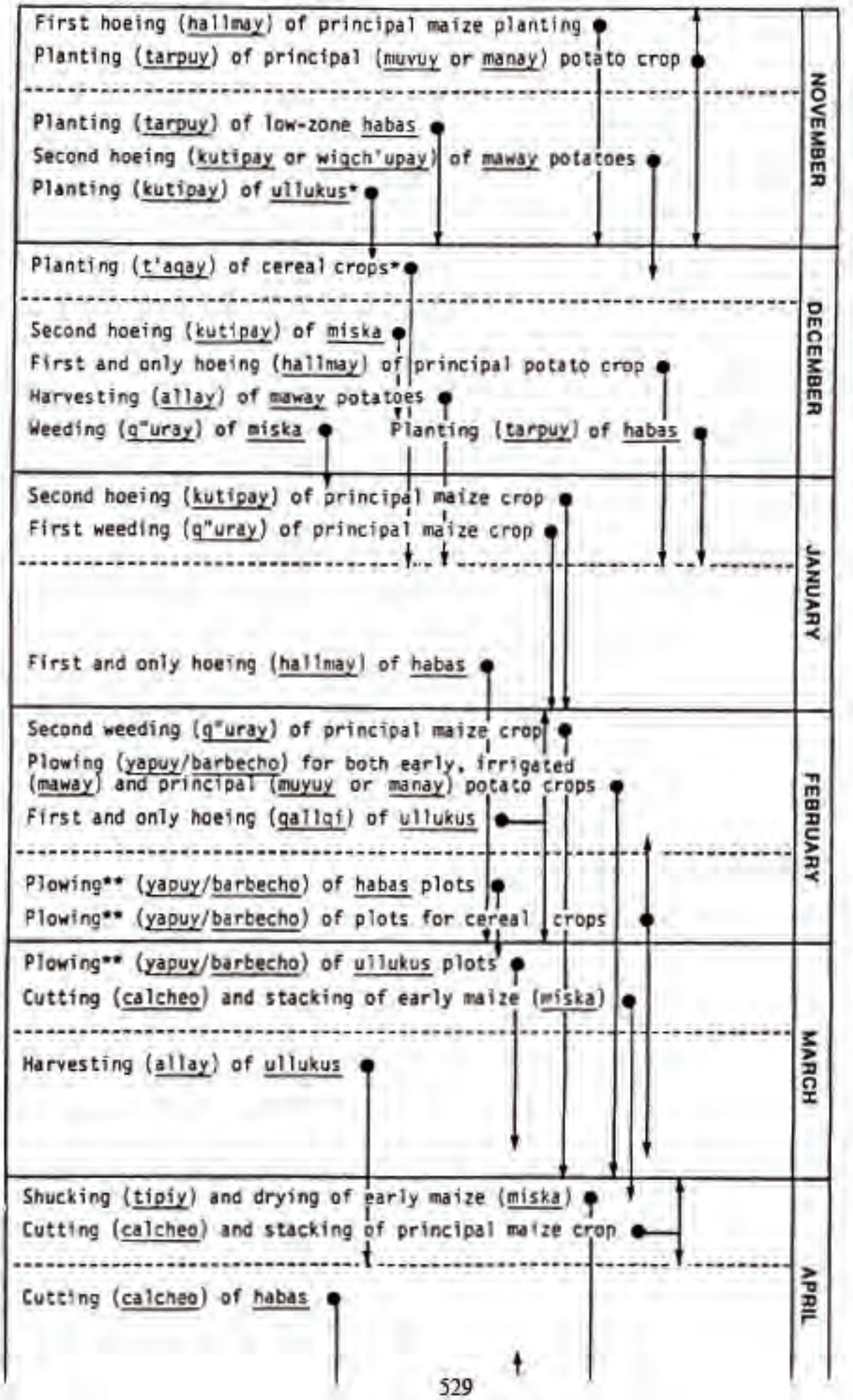


FIGURE 3

THE ANNUAL AGRICULTURAL CYCLE OF USI



NOTE: Dotted lines represent the temporal--if not the visual--midpoint of the month. They are spaced unevenly on the Figure due solely to reprographic and chart-size constraints.

FIGURE 3, continued

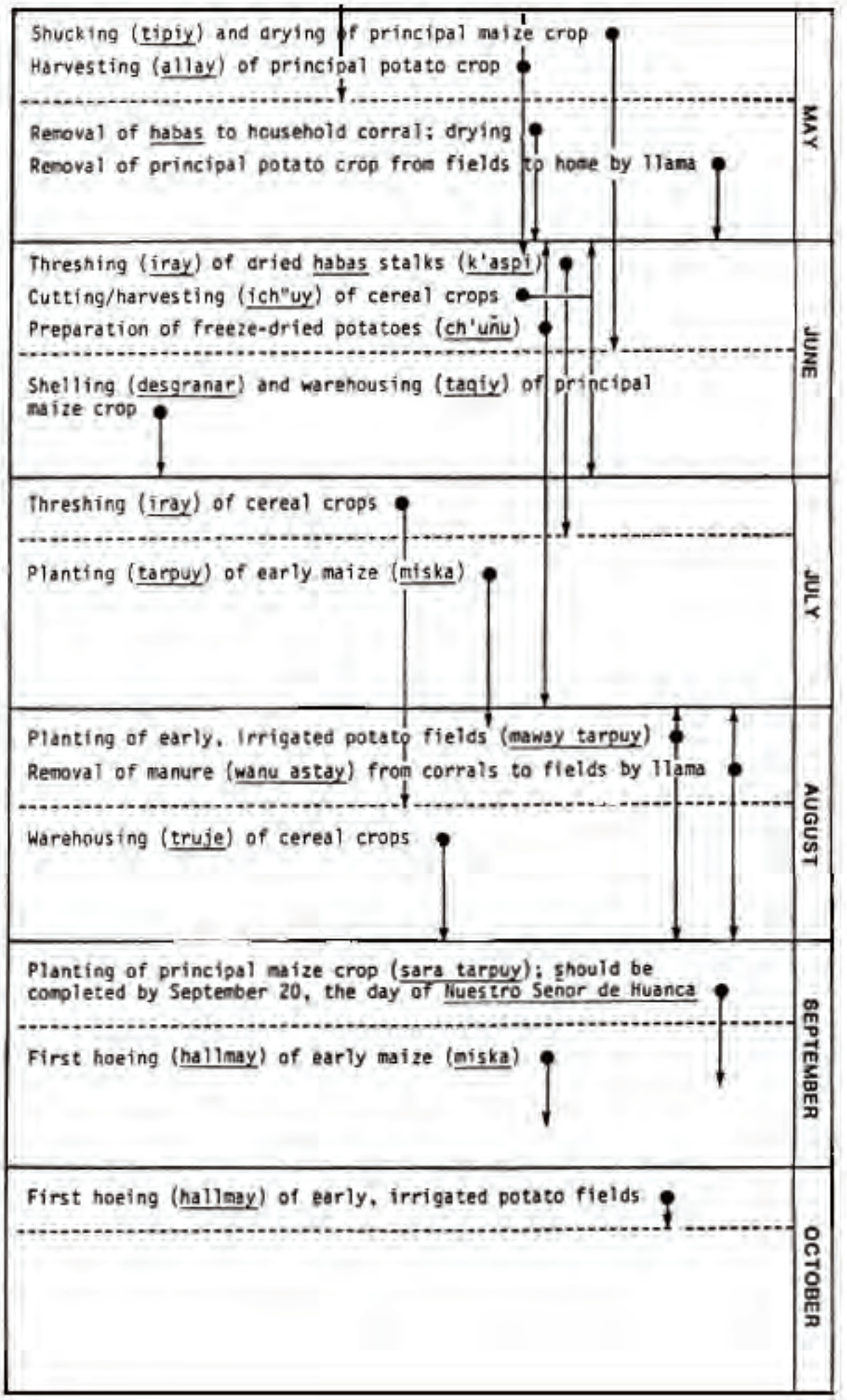
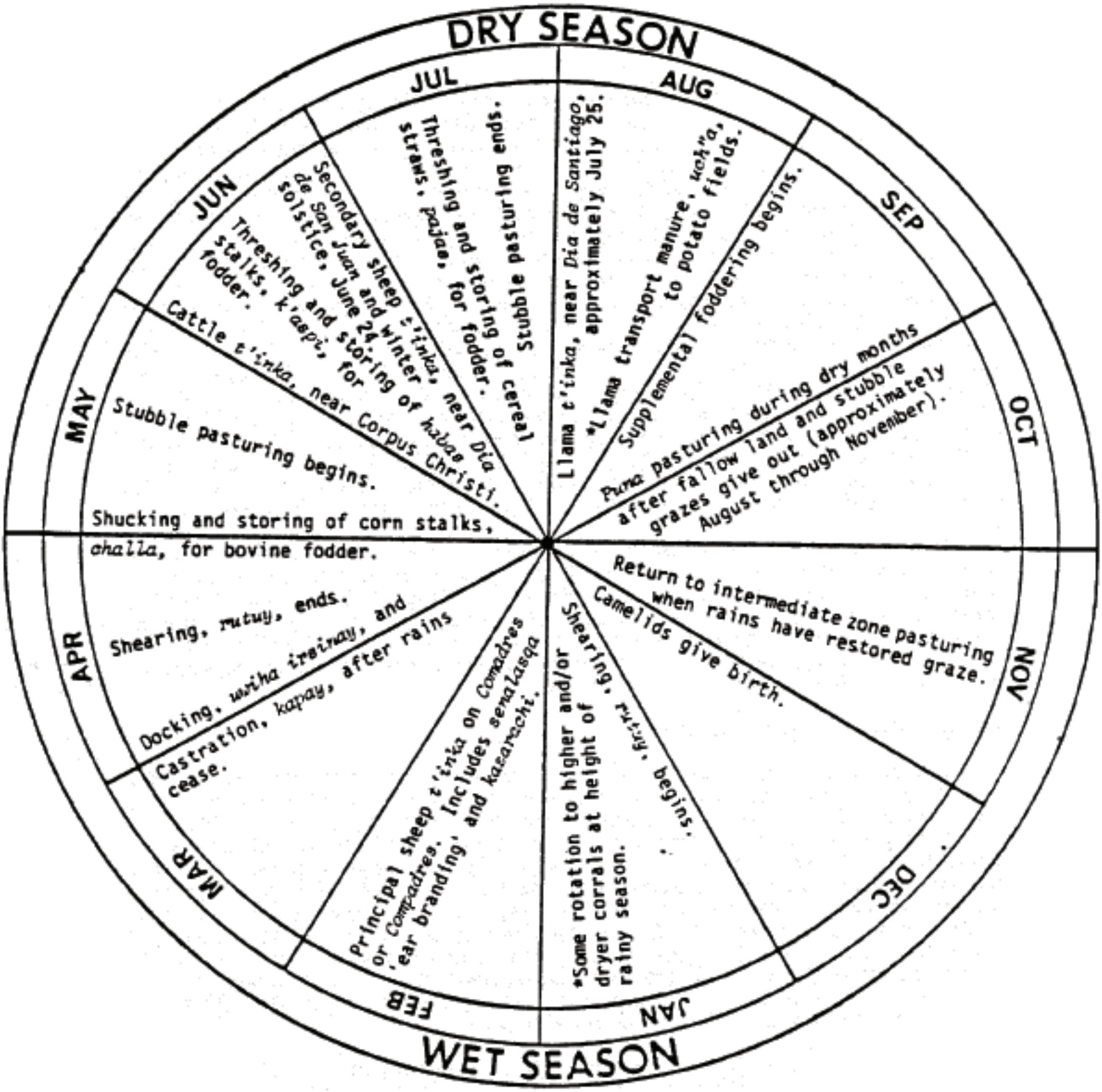


FIGURE 4

THE ANNUAL PASTORAL CYCLE OF USI



METHODOLOGIES FOR CONDUCTING ON-FARM LIVESTOCK RESEARCH WITHIN MIXED FARMING SYSTEMS

Mark A. Kujawa* and James W. Oxley**

Introduction

Farming systems research methodologies were developed initially with a focus on agronomic trials. It was not until recently that researchers recognized the importance of including animal studies in farming systems research. The methods used for conducting on-farm livestock research (OFIR) were developed from experiences with cropping trials. But because of unique problems and constraints, many crop research methodologies proved inadequate. The design of animal experiments may be doubly difficult because the variables associated with agronomic on-farm research are often involved in forage production and combine with the problems of animal experimentation. Research with large animals limits the number of replications because of their high relative cost, diverse genetic background, variation in age, condition, and past nutritional history. The science of biometry developed from agronomic research was slow to be adopted by animal research centers. Its application to OFIR presents difficult problems. Likewise, the lack of communication and interaction among animal scientists conducting on-farm trials with livestock suppressed the dissemination of experimental methodologies. As a result, conferences on research methodology were held in Ethiopia, Syria and Togo to bring together researchers and develop guidelines from past experiences. This paper is based on topics and methodologies presented during those meetings.

The purpose of this paper is to present methodologies considered important by researchers when conducting OFIR. The areas discussed include the selection of the research site, farm selection, farmer participation, experimental design, data collection and the analysis of research results. These topics do not represent all the components of on-farm testing using the farming systems approach. However, they reflect areas from past experiences which were emphasized and well documented.

Research Site and Farm Selection

The selection of a research site and subsequent participating farmers should result in an area where the research results are transferable with some degree of predictability to a larger area (Thomas et al., 1982). The site selection process should define a group of farmers with similar livestock and husbandry practices. If major differences exist between regions, more than one site can be selected. Without defining a homogeneous group of farmers for making recommendations, research results may not be applicable or could even be damaging. Shaneret al. (1982) has described criteria for selecting research areas. The representativeness, size, accessibility, and closeness to an experiment station of the area and the cooperation with farmer agencies are discussed. Experience has sham that when conducting OFLR, additional criteria are needed to define an acceptable site.

Site selection criteria. In selecting a research site, villages or areas must be stratified on the basis of criteria important to the research team. However, not all criteria are directly related to defining distinct populations. Bundersonet al. (1985) suggested that the region should be a major production area, have a high population density and the agriculture sector must have potential to develop. Resource availability, ease of access,

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available baseline information, and village leader cooperation are also important (Ahmed et al., 1985; Thomas et al., 1982; Bunderson etal., 1985). The use of parameters which reflect livestock populations and management can stratify farmers into discrete groups. The region's physical characteristics are important, for they directly influence agricultural practices (Bunderson et al., 1985). Agricultural activities are the primary criteria used in many site selections (Thomas et al., 1982; Bemsten, 1982). The strong interaction between crops and animals suggests that grouping farms with similar agronomic conditions and practices will produce groups of homogeneous farms based on animal husbandry practices. Often it is assumed that farms which have similar feed resources produce similar animals. However, Thomas et al. (1982) found this not to be true when competing studies in west Java. Animal management systems (e.g., traditional or semimodernized), and the mean animal population density have been used to stratify sites according to animal parameters (van Eys et al., 1985; Ahmed et al., 1985).

Because some of the criteria suggested are highly subjective they become difficult to prioritize according to their importance. Thomas et al. (1982) suggests that because program development depends cm institutional cooperation, it is highly unlikely that research sites can be selected by objective criteria alone. A combination of subjective and objective criteria must be involved in site selection.

The data obtained from baseline surveys should provide information about the relationships between the animal production system and the physical and socioeconomic environment. By using the pertinent criteria, sites and farmers are differentiated into homogeneous groups. However, the criteria selected may not always produce distinct classes. A study described by van Eys (1985) used agricultural activities, animal management, mean animal population density, and leader cooperation for village site selection. Farmers were selected from the baseline survey using a proportional, stratified random sampling technique with land ownership as the main strata and animal ownership as the substrate. The effectiveness of this methodology was studied by Thomas et al. (1982). It was found that sheep and goats performed the same at each site in terms of growth performance, even though there were differences in structure and management of the small ruminant enterprises between sites. The research sites were not different with respect to growth parameters as was originally thought. Farm size or ownership is used often in agronomic studies and is known to influence cropping patterns (Thomas et al., 1982). Farm size was used as a criterion for this study because it was assumed that size would determine feed resources and affect growth variables. However, Thomas found that there was no relationship, as feed was purchased off-farm. To improve the stratification of populations, he recommended that initial surveys be used to provide more information about the system so farms can be grouped "on the basis of parameters found to be quantitatively related to the enterprise under study." In addition, he recommends that the quantitative parameters related to the biological factors of the farm should be measured over time to describe better a dynamic livestock system.

Sampling methods can also affect site and farmer selection. The use of random sampling can create the risk of drawing from different populations (Mclntire, 1986). If sampling is done from volunteers, homogeneity may be eliminated by the selective bias of collecting information from progressive farmers only. Sample size is affected by cooperation. Ideally, a large number of randomly selected farmers result from a baseline survey. However, the opposite is usually the result. A trade-off occurs with random sampling and cooperation (Tully et al., 1985).

Farm selection. The criteria for selecting farms to participate in OFLR are again based on the goals of the research team. The farmer must be able to supply the species and number of animals needed throughout different seasons and length of the trial (Ahmed etal., 1985). This becomes very important when conducting trials which collect data for more than a year (e.g., reproduction). Animal ownership is an important criterion (Gryseels and Anderson, 1985). Insane cases, animal ownership may be difficult to determine due to complex agreements between different groups and families. OFLR conducted within such systems may not be possible as owner consent is generally a prerequisite for participation. When conducting grazing and animal traction studies, the ability to provide land is important (Tully et al., 1985). In some cases, the farm must be secure from accidental grazing. Cooperation with the research team generally determines if the farmer will be used for the trials (Ahmed et al., 1985 ; Tully et al., 1985 ; van Eys et al., 1985). A cooperative attitude is considered more important in livestock trials because of the increased management changes needed to conduct OFLR (Tully et al., 1985). Certain farmer characteristics can influence their selection. Conviction of the project and willingness to try, ability to perform the test, literacy, and patience for recurrent team visits can be important (Bunderson etal., 1985; Sidahmedet al., 1985; Ahmed etal., 1985; Hadjipanayiotou, 1985). The amount of experience with previous research projects will affect farmer selection. Gryseels (1984) found that farmers with no previous research association and those who participated voluntarily were preferred for OFLR. These farmers were interested in the technology and participated for the length of the trial. Also their evaluations were not biased from experiences with past studies. A trade-off occurs with using volunteers and selecting nonexceptional farmers (Tully et al., 1985). Volunteers may often be the progressive farmers and not representative of the population (see site selection criteria). In contrast, Modawi et al. (1985) preferred to use farmers who had relatively more experience in the enterprise of interest. Tully et al. (1985) reported that farmers should not be closely related. Collaboration between families during a trial could increase nontreatment error by altering or exchanging assigned treatments between farmers. The farm's location, accessibility and its distance from the research center can also have a large effect (Tully et al., 1985; Hadjipanayiotou, 1985). In some regions these criteria become very important due to lack of transportation and rugged terrain.

Farmer Participation

Farmer participation is an important, but often overlooked area when conducting research. It can determine the success or failure of anon-farm trial. The way in which farmers are incorporated into the trial will influence the success of future trials as well. This section will discuss farmer participation and the use of incentives and compensation during OFLR.

Participation. As stated above, the participation of farmers can affect the outcome of the experiment. Without it, no OFLR can occur. What induces farmers to participate in an experiment? Incentives offered by the research team would appear ta be a primary reason. Modawietal. (1985) stated that cooperation brings benefits. Many types and forms of direct incentives have been used and will be discussed in the following section. Besides direct incentives, there are indirect ones that also are apparent to the farmer. In a sheep trial conducted by Hadjipanayiotou (1985), farmers that participated could sell their animals for a higher market price. It was well known that

participating farms produced sheep superior to those traditionally raised. This created more interest in the project and increased participation.

Compensation and incentives. Condensation for farmers are primarily offered to increase participation by reducing the risk and inconvenience associated with an experiment (Tully et al., 1985). This is more important when conducting OFIR than with agronomic studies. The loss of a single animal can result in a large economic loss to the farm family. Likewise, the change in management practices associated with a new animal technology are greater than a change in a cropping system. By offering incentives, the farmers gain trust in the researcher and helps insure the testing of new technologies.

The degree of compensation or incentive is a function of the degree of risk involved with cooperation. For example, a farmer would need more compensation when conducting trials on the farmer's land and using the farmer's own animals compared to trials where the farmer's personal involvement or animals is limited. A large compensation package of credit and insurance may be required when farm animals are put through unfamiliar feeding practices, while only slight technical assistance is needed when conducting researcher managed trials. The level of importance of animals on the farm and the level of investment may determine the amount of farmer involvement (vanEys etal., 1985). This can also influence the amount of compensation needed by the farmer. If the level of investment and importance are low, relatively less compensation is needed to induce participation than on a farm where the investment and animal importance are high.

There can be disadvantages when providing incentives. It may become difficult to evaluate farmers' opinions concerning a new technology, as farmers are influenced by the type and level of compensation (Hadjipanayiotou, 1985). The use of free supplements may have biased the reaction of the farmers and led to false conclusions about the technology. If the level of compensation falls short of farmers' expectations, they may reject a technology because of their dissatisfaction with the compensation and not the technology. In livestock trials conducted by Gryseels (1986), no direct incentives were offered. It was felt that any inducement to participate would interfere with a true evaluation of the rate of adoption. Farmers would participate only to receive the incentive. After removal of the incentives, farmers would drop out of the experiment.

The type of incentives and compensation offered are as varied as the OFIR. Feedstuffs are used in different ways. When new feed resources are introduced, they are generally given to farmers to test on their animals. Feeds can be sold to farmers in order to overcome temporary shortages during a drought (Gryseels etal., 1985). This not only compensates farmers for their losses, but allows the trial to continue (Nour etal., 1985). Feeds can be subsidized or given as compensation for testing technologies other than nutrition (Tully etal., 1985). For example, if certain feeding practices are being measured, compensation in the form of a feed already being fed could change the management practice under study. Tully suggests that if farmers are feeding barley, then compensation should consist of another feedstuff such as wheat. When introducing new species to a region, farmers are generally provided with animals. To ensure participation throughout the trial, same form of agreement is necessary, Goats were introduced to a farming system and given to farmers as incentive to participate (Sidahmed et al., 1985). After one year on the experiment, farmers took ownership of the goats. In another goat trial, farmers received one mature goat or sheep with the stipulation that they return three post weaning offspring over a five year period (van Eys

étal., 1985). Implements are offered when introducing animal traction (Gryseels, 1985). During the introduction of single oxen power for crop cultivation, plows were sold to the farmers. Production inputs can be used to supporta new technology. With the introduction of goats, participating farmers lacked the necessary milkirg equipment (Sidahmed etal., 1985). It was supplied to the farmers in addition to vaccinations and disinfectants. While all were available locally, they were given to farmers as incentives. Free services have been used with different trials. Although farmers enjoy this type of incentive, there may be social constraints which limit its use. Bunderson et al. (1985) found that farmers became suspicious that "nothing goes for nothing." A s a result, he recommends that a nominal fee be charged for all services and inputs. Of all the incentives mentioned above, cash has the greatest appeal. In particular, it has been used for payment of field labor, use of land and for housing technicians (Sidahmed et al., 1985). It can be used to insure against losses during the trial and given in the form of operating loans (Gryseels et al., 1985; Hadjipanayiotou, 1985; Sidahmed et al., 1985). Other types of nonconventional incentives have been used with some success. A guarantee can be given to farmers to insure the return of a collected sample. This becomes important when measuring milk production (Sidahmed et al., 1985). Hadjipanayiotou (1985) used organized competition between participating farmers. This helped promote interest in the project by creating friendly competition and publicly demonstrating the advantages of using the new technology.

Experiences from OFIR have shown that farmer participation is an important factor in the success of any trial. Incentives, either direct or indirect, are needed to compensate farmers for the risk and inconvenience. The amount and type of incentive are functions of the amount of riskiness and type of trial conducted. The higher investment in livestock and lower numbers of animals makes OFIR more risky than agronomic studies. Work with cattle demands more compensation than studies with smaller ruminants. Negative effects can arise from using incentives. These should be recognized at the beginning of the trial so that an increase in farmer participation does not come at the expense of unbiased information.

Experimental Design and Testing

During the testing phase, the research team will design trials which measure the performance of different technologies, compare new technologies with traditional practices, and identify new resources and production constraints. Studies can be oriented to test for significant differences, the adoption of a technology, basic research or allow farmers to experiment independently (vanEys etal., 1985; Okali etal., 1985). The most prevalent method is to measure productivity through control of certain experimental parameters and test for differences by using various statistical models. This generally occurs when corseting researcher managed trials. It has been reported that tests for significance are difficult to produce with OFIR (van Eys et ad., 1985; Gryseels and Anderson, 1985; Mclntire, 1985; Petheram et al., 1985). There exists a high risk of confounding treatment effects with environmental effects due to large variations between animals and farms. This confounding leads to inefficient estimators of treatment effects and decreased confidence in making recommendations (Nblntire, 1985). Other problems with testing include no within farm replications, no control group, few animals, multipurpose animal output, and environmental effects that increase nontreatment variation (Gryseels and Anderson, 1985). This section will discuss methodologies and experiences in experimental design, experimental units, replications, and data collection.

Alternative testing procedures. The majority of testing with livestock is oriented towards using statistical models and tests of significance to evaluate innovations. Because small differences in treatments are difficult to detect, an-farm testing should not be used for basic research (Bernsten, 1982). Animals are difficult to pair and replicates are few. These factors, so important in basic research, can be better incorporated into on-station trials. To detect such small differences on the farm would require a large amount of control. If much control is needed, the technology would probably never be adopted by the farmer (Bernsten, 1982). Because of the difficulties mentioned above, alternative testing methods may be appropriate. When extreme variation exists between farms, Zandstra (1985) suggests that surveys can be used to gain insight and information about the, system without testing. Similar methods are used by farm management and social science professionals. A second alternative, allowing farmers to experiment with a new technology, is seldom used by researchers (Okali et al., 1985). Atta-Krah (1986) reported the use of farmer experimentation in the introduction of alley farming. Farmers were given seed and advice on how to utilize fodder trees. The farmers decided how best to incorporate the technology into their system. This method of evaluation provides information on which innovation they perceive as beneficial and directs future research. Okali et al. (1985) outlines the methodology for utilizing this form of testing. A new technology is implemented on an animal or animals followed by a visual evaluation of the difference between treated and control animals. This assessment would then be combined with past experiences or alternative technologies. The farmer would also evaluate how it affected other areas of the farm. Farmers' perceptions would form the basis for accepting or rejecting the technology.

Experimental design. Harvey (1986) has outlined two basic experimental designs which are applicable to OFIR. The first concept deals with a cross classified design where treatments are compared with farms. Here, all treatments are tested on the same farm. Farm and treatment effects are considered as well as other sources of variation. Age of animal, sex and time of measurement are but a few sources of nontreatment error. Generally, this type of experiment is not possible when testing large ruminants. Farms lack sufficient number of animals to test all treatments. The problem with small numbers of animals is not limited to cattle. In some regions, there may be only two or three sheep and goats per farm (van Eys etal., 1985). Where large flocks of sheep or goats exist, this design may be considered. When enough animals are available for testing each treatment, the question arises as to whether it is more beneficial to increase the number of animals tested per farm or increase the number of farms. While testing feedlot cattle Ahmed et al. (1985) preferred to use more animals and fewer farms. They found that by increasing the number of farms, a more representative sample was obtained but travel increased significantly and fewer treatments could be tested. Their objective was to obtain as much information about numerous treatments as possible.

The second design discussed by Harvey involves the application of a single treatment per farm. Farms are randomly chosen to test each treatment which nests farm effects within treatment effects. When pairing farms, farm effects will be large, resulting in the need to use many more farms than in the first example. This design tests acceptability of new technologies but is inefficient. The use of different farms for replicates confounds treatment effects with farm effects (Sands et al., 1984). This limits precision and makes treatment differences difficult to detect using standard levels of significance (van Eys et al., 1985). To improve precision, it is recommended

that the number of treatments be limited while increasing the number of farms. The decision to use either of the two models is dependent on different factors. As mentioned above, the number of animals available on each farm is a major consideration. The amount of variation between animals also affects the choice of models. If variation between and within farm animals is large, only one treatment per farm is possible. Van Eys et al. (1985) found that variability between farms was less than within farms when measuring weight gains and performance. The variability in flock characteristics, feed sources, farm management, and animal husbandry practices made more than one treatment per farm impossible.

Disproportionate subclass frequencies are common in OFIR (Harvey, 1986). It is difficult to maintain equal classes throughout the trial. However, if the statistical model used demands equality, certain adjustments can be made to account for lost observations. The following example outlines the procedure used by van Eys et al. (1985). A completely randomized block design was used with level of productivity as blocks and farm size as covariance. The criteria used for blocking were mortality, post-weaning gain, and gain corrected for litter size of goats. Equal treatment groups were maintained by eliminating farmers from the group as others voluntarily left the study for various reasons. Stability of the flock, in terms of size and composition, determined which farms would be removed.

Replication. The replication of treatments is an important component of any experimental design. It provides estimates of experimental error, improves precision by reducing the standard deviation of treatment means and increases the scope of inference (Steele and Torrie, 1980). The more replication possible, the more information available from the experiment. However, increased replication requires sampling from a less homogeneous population which results in a larger experimental error. In OFIR, replicates usually occur on different farms (see Experimental Design). The amount of variability between farms will determine the number of replicates needed to detect significant differences between treatments. While no recommendation will be applicable for all situations, past experiences offer general guidelines for treatment replication. Replications are most important when testing treatments (Zandstra, 1985). It is less important when sampling farm types. A good representative sample iron the adoption domain is more effective. Zandstra (1985) also recommends that a trial begins with fewer replications and more treatments. As information is collected, the number of replications should be expanded and the number of treatments reduced. For example, when six treatments are tested, twelve farms are needed to participate. Two replicates per treatment are used. The following year, three treatments were imposed on twelve farms. An increase in the number of farms is possible as well. This same format was suggested by Oxley (1985) for evaluating the introduction of animal traction. The number of replications should be a minimum of six farms with an additional six farms representing the traditional system. Van Eys et al. (1985) found that in order to detect a 20% difference at P=.05, seven or eight farms per treatment were needed when testing nursing lambs and kids. Only four or five replicates were needed if testing was done with weaned animals. The differences in replicates were due, in part, to the larger diet effect an the preweaned animals. More variation was seen within this group than between the weaned animals. The sample size was twenty farms in a trial conducted by Bunderson et al. (1985). Ten replicates were used for each of two treatments. Farms were located in the same village to reduce variation.

Experimental units. An experimental unit is described as the unit of material where the application of a treatment is applied. As with all trials, the experimental unit is dependent on the focus of the research. Tully et al. (1985) and Petheram et al. (1985) used individual animals while Zandstra (1985) and Oxley (1985) discussed using pairs of animals as experimental material. Pairs are the best way to reduce variation, however, effective pairing of animals is generally impossible (Zandstra, 1985). Fear of new technologies, lack of animals and misunderstandings of the testing procedure cause reluctance by farmers to commit more than one animal to the trial. Flocks or whole herds can serve as experimental units. Measures of herbage intake of grazing animals or reproductive parameters may best be recorded from groups of animals. When the objective of the trial is to study farm types, the farm may be the experimental material.

The selection of animals for a trial is usually left to the participating farmer. A certain amount of bias will result with the farmer's selection. To avoid uncertainty and reduce potential losses caused by the study, the farmer may select the poorest animals. Conversely, the best animals may be chosen in order to satisfy the research team. Social or religious ideas can also affect the farmer's choice. As a result, the experimental animals may not represent the general population. While a completely random sample is difficult to obtain, the farmer's selection methods offer valuable information on the relative importance of different animals and the farmer's perceptions of the experiment. In some cases, the research team may be required to purchase animals as replacements or to do initial testing of new species. Limited availability of animals may make it difficult to acquire a sample with the proper characteristics. Fadlalla and Cook (1985) found that healthy and physiologically correct animals needed for their study were difficult to buy at local markets. The need to make unplanned, repeated trips to the market used scarce project resources. If the inherent biases and difficulties in selecting experimental animals are recognized at the trial's beginning, new information on farmers' preferences can be identified and incorporated into future experiments.

Control of environmental effects. Researcher or farmer managed trials are two types of experiments used with OFLR. The decision to use one or the other depends on the degree of control wanted. Researcher managed studies are said to provide more control, improved cost/benefit estimates and a better evaluation of potential technologies (Bunderson et al., 1985). As the farmer gains more control of the experiment, variability of most production parameters increases. Along with variability comes the increased risk of nontreatment error. Two types of nontreatment error have been identified which affect OFLR (Mclntire, 1986). Covariate risk affects the whole sample or population. The effects are not generally correlated with treatments. For example, because of nonrestrictive grazing, animals eat a variety of forages and create difficulties in quantifying the effects of feeding trials (Atta-Krahetal., 1985). Mclntire suggests that this type of error acts only as a source of inefficiency in the estimator and not a bias unless mobility is caused by the treatment. Therefore, no restriction of grazing is needed. Death or sale of an animal during the trial constitutes a specific effect. Such an effect on the experimental unit is generally unrelated to the treatment and cannot be controlled, thus resulting in lost observations. The effect on the experiment of a sold animal will depend on its characteristics. It could have a large effect if the animal was the best or worst of the group.

While many environmental effects cannot or should not be controlled, it may become necessary modify the protocol in order to continue testing the

intervention of interest when conducting researcher managed experiments. Many unforeseen effects, like adverse climatic conditions, have the potential to end trials if experimental procedures or objectives remain unchanged. Likewise, changes initiated by the farmer during testing could lead to increased nontreatment error. The following examples came from experiences where modification or control was necessary in response to a specific environmental effect. While conducting feedlot trials, a drought and famine caused significant changes in meat and feed prices (Ahmed et al., 1985). Subsequently, feeding practices under study were modified by the farmers. Grain was then provided at subsidized prices so farmers could again continue their "normal" feeding practices and the trial could continue. When the researcher conducts nutrition studies, it becomes important to quantify the basal ration. However, the quality and quantity of feed is highly variable between farms and seasons (Petheramet al., 1985). During a trial, this causes large differences between similar treatments. Therefore, nonsignificance may be the result of treatment variability and not from variation independent variables (Petheram et al., 1985). Petheram suggests that basal rations be tested regularly throughout the trial and that farmers be grouped according to their feeding ability and feed resources. A control group must maintain their normal feeding practices in order to effectively compare treatment results. Petheram et al. (1985) found that control farmers vera influenced by neighbors who were testing different treatments. They increased supplementation to their own cattle upon noticing feed changes within treatment farms. The effect of neighbors cannot be overlooked when monitoring husbandry practices. Likewise, it is difficult to know with certainty about-the treatment of control animals without developing a placebo treatment (Petheram et al., 1985). One method, described by Petheram et ad. (1985), recommends that the "control" group actually receives a complete supplement and the treatments are deletions rather than supplements. Variation in feeding frequency is a common problem. Petheram found that some farmers would finish their monthly allotment of feed in three weeks. One solution would be to prepare separate bags of the daily supplement. However, this would remove the ability to analyze the farmer’s adaptation to a new technology. Farmers may change the composition of the experimental ration during the trial. Lactating cattle were tested for effects of hay supplementation during the dry season (Bundersonetal., 1985). To maintain milk production, farmers could supplement the ration with a locally produced seed cake when available. This practice conflicted with the study of hay based rations. To avoid conflicts with the farmers, nonlactating, nonpregnant females became the experimental unit. A trade-off between initial objectives and farmer interest occurred in order to continue the study. An experience from studies in animal traction demonstrates that farmers may substitute animals. Trials in the introduction of single oxen implements were affected when farmers substituted tired animals with fresh oxen or reverted to two oxen plowing techniques (Gryseels, 1986). Social (Commitments restricted field preparation on private plots. In order to insure completion of their own field work, farmers would resort to using a two oxen system. They perceived the new single ox system as inadequate before it was tested. Although these types of effects are difficult to control, they provide additional information which can be used to adjust future experiments.

Data collection. During the experiment, there is always compromise between the need to collect adequate data on experimental variables and the difficulty in doing so (Thomson, 1984). When planning the experiment, Thomson recommends that a list of variables be constructed and ranked according to their importance. Not only is researcher importance a criterion, but the farmer's criteria should be considered as well. The research team should consider variables which are noticed by the farmer in the shortest period of

time (Thomson, 1984). Rapid detection of treatment effects is essential in maintaining farmer interest and participation. Difficulty in collecting data may exclude a variable from the list regardless of its importance. Therefore, a careful evaluation of each variable should be undertaken before starting the experiment.

The collection of qualitative data during the trial is a unique characteristic of on-farm research. It involves recording farmers' observations and comments concerning the new technology. Likewise, a visual interpretation by the research staff gives valuable information on treatment effects which are difficult to quantify. Observations are generally recorded by interviewing farmers during periodic farm visits (Sidahmed et al., 1985). Farm field days offer additional opportunities to obtain farmers' insights prior to farm testing. The frequency of recording qualitative data is dependent on the project's resources and the amount of information required. Van Eysetal. (1985) found that one staff visit per month was sufficient. However, the large distance between farms limited visits to two per day. With a large sample size, less frequent visits may result. Farmers should also be notified in advance of the visit. This helps insure the farmers' presence and improves time management. As farm communication is difficult, it is suggested that a visitation schedule be agreed upon at the beginning of the trial.

Due to the nature of OFLR, most quantitative data collection procedures need modification. To suggest recommendations for each method is beyond the scope of this paper. However, several papers offer an excellent description of various methods. Detailed data collection procedures during grazing trials may be found in van Eys etal. (1985) and Sidahmed et al. (1985). They discuss measurements of various animal and forage parameters including the use of esophageal fistulated goats. Starkey and Apetofia (1986) present methods for testing implements used in animal traction. In testing mineral supplements, McDowell etal. (1986) discusses several techniques. Body weight and milk production are variables common to most livestock trials. Therefore, several suggestions for collecting data on these parameters are outlined below.

Monitoring weight changes is a common activity with OFLR. An animal's weight reflects feed intake, feed quality, and levels of work and production (Starkey and Apetofia, 1986). The variability in body weight during any point in time can be affected by gut fill. This factor makes accurate measures difficult with large animals. Several trials outline procedures which address the problems of weighing animals. Weights were recorded at the beginning and end of trials conducted by Bunderson et al. (1985) and Hadjipanayiotou (1985). During longer trials, Sidahmed et al. (1985) weighed sheep and cattle every fourteen days. To adjust for differences in gut fill, Tullyet aú. (1985) weighed for inconsecutive days at the beginning and end of a twenty eight day period. In contrast, a minimum of four postweaning weights are recommended to evaluate treatment effects with lambs (van Eys et al., 1985). The two most common weighing methods are scales and heart girth measurements. Scales must be portable if used for OFLR (Ahmed et ad., 1985; Starkey and Apetofia, 1986). Portable load cells can be used in place of scales (Starkey and Apetofia, 1985). Calibration can be done at the site, but animals sometimes resist entry. Heart girth measurements are inexpensive and easy to use. However, differences in measuring techniques between technicians can cause large weight differences from the same animal. Therefore, the same technician should measure the same herds or animals each time. Starkey and Apetofia (1986) recommended that heart girth measurements be used only in the assessment of general weight trends. At most, measurements should be done monthly or bimonthly throughout the trial. A condition scoring system may be

an alternative to the above methods. It can alleviate problems associated with gut fill and farmer inconvenience. The condition score should be farmer developed using farmers' terms (Starkey and Apetofia, 1986). For example, participating farmers in a study reported by Nour and Hamza (1985) used flank measurements, brisket size and hair coat condition as their criteria. If farmers are unable to develop a system, other experienced local people may be called upon (Starkey and Apetofia, 1986). Meat traders or buyers could develop a system using criteria important to marketing beef animals.

Because of its important economic and social value to small producers, milk production is a dependent variable for many trials. While measured to evaluate dairy production systems, monitoring milk output has been recommended as an efficient, indirect indicator of treatment effects (Tully et al., 1985; Thomson, 1984). For example, farmers can see changes in milk production faster and easier than in body weight. Milk production is difficult to quantify while animals are nursing (Hadjipanayiotou, 1985; Mbdawi et al., 1985). In order to adjust for suckled milk, Modawi et al. (1985) measured milk from two or three quarters to calculate total production. They assumed equal production from all quarters. However, many factors are known which cause milk production to be unequal. Physiological differences between front and rear quarters, effects of mastitis and dry quarters challenge this assumption and lead to erroneous estimations. Nursing young can be removed prior to milking. Sidahmedet al. (1985) separated Kids from their dams eight hours before milking. Depending on the facilities, this may or may not be a viable method. Regression equations constructed from on-station research have been used to estimate milk production (Hadjipanayiotou, 1985). Body weights from male and female offspring taken during on-station research are correlated with total milk production from dams. Weights from on-farm offspring are then used as estimators. However, differences ingrowth patterns between farm and research station animals may make regression estimates unreliable. Human error also contributes to the difficulty in collecting milk samples. In some societies, milking is the sole responsibility of women and serves as their only source of cash. Fadlalla and Cook (1985) found that women milkers would remove a portion of the sample for their own use before it was weighed and recorded. To ensure an accurate weight, women were replaced with men to reduce losses from theft.

Analysis of Experimental Results

The analysis of research data collected from OFIR incorporates the use of different analytical techniques. The goals of any systems research go beyond the determination of conventional biological parameters (Lightfoot, 1984). Traditional experimentation deals with means and utilizes productivity as the only criterion for the final evaluation. To more accurately simulate the farmer's decision making process, data collected during OFIR must allow for biological, economic, social, and acceptability evaluations (Olson et al., 1986). The utilization of these four parameters allows the team to make recommendations that will hopefully have a positive impact on a large number of farmers. Unfortunately, detailed documentation of incorporating more than biological and economic analysis into the evaluation process is very limited. This section will report analytical methods used in evaluating biological, economic and empirical data associated with OFIR.

Biological analysis. Analyzing any technology usually begins with the evaluation of a biological response. The team attempts to determine if the technology produced more from a set of resources, utilized less resources or stabilized increasingly scarce inputs (Shaner et al., 1982). The difficulty

in showing statistically significant differences between treatments has already been discussed. Large coefficients of variation for most production parameters, the difficulty in identifying linkages between parameters and the confounding of farm effects contribute to large nontreatment error terms (Gryseels, 1986). As much nontreatment error as possible should be removed by statistical methods. If the use of statistical models is required, the analysis should start with simple descriptive statistics (Atta-Krah, 1985; Oxley, 1985; Ahmed et al., 1985). These include range, means, variance, standard deviations, and standard error of the means. Such parameters are derived from the comparisons of animal response and performance between treatments, treated farms with control farms or treated and control farms with research stations (Ahmed et al., 1985; Gryseels, 1984). Controls should only be compared with treatments if sufficient experimental control was possible. If uniformity was lacking, comparisons are unreliable (Oxley, 1985).

While the analysis of means is important to the researcher, it may not be relevant to the farmer. Lightfoot (1984) suggests that recommendations cannot be based on the analysis of means. Farmers are more interested in the range and stability of animal performance than average production. He also postulates that mean data may not be reliable and the accuracy is questionable. To analyze data in terms of the farmer's criteria, Lightfoot (1984) recommends the use of one of three methods. While the methodologies are oriented towards crop research, they may be applicable for livestock studies. First, interquartile ranges and confidence intervals can be used to estimate the range of outcomes under different conditions. The conditions where new technologies perform poorly and where they perform well are known. For animal research, these conditions may be different levels of management or resources. With this method, the use of experimental failures can be incorporated into the analysis and become useful data. Second, a method called the modified stability analysis evaluates two or more treatments from a range of environments in order to partition farmers into recommendation domains. The variation of treatments between different environments is estimated by regressing outcomes against an environmental index. Calculation of an environmental index involves averaging the effects of all treatments at one location. If there are more than ten locations, each location becomes an index. When there are fewer than ten, the index is derived from each replicate. By combining response curves fron two treatments, environments are identified where one treatment is superior to the other. There are several difficulties when using this type of analysis for livestock trials. Locations may not be appropriate for determining environmental indices. Within the research site, differences in management may define an environment more clearly than location. Indices could be defined as different management levels. With agronomic studies, the replication of many treatments at different locations allows for the creation of many environmental indexes. The wider the range of environments that can be incorporated into the analysis, the better the results. However, the nature of OFLR limits the number of environments or management systems studied and the number of possible replications. Increased documentation or use of the modified stability analysis is needed to further refine the technique for livestock trials. Third, Lightfoot recommends that the risk of failure to those who adopt the technology could be estimated by calculating the probability of failing to reach specified disaster outcomes. For example, during a drought or disease outbreak, what is the likely outcome and the associated probability of occurrence for each treatment? Like the modified stability analysis, no documentation is available to fully evaluate the methodology.

Economic evaluation. Increased biological production is not enough to recommend a technology (Tully et al., 1985). A comprehensive economic

analysis is also needed to evaluate an intervention. To fully address the complexities of economic analysis is beyond the scope of this paper. An excellent, practical bulletin by Perrin et al. (1978) discusses major economic parameters and outlines specific methodologies when conducting on-farm research.

A partial budget analysis is used most often when conducting OFLR (Zandstra, 1985; Sidahmed et al., 1985; Ahmed et al., 1985; Tully et al., 1985). Technical data and market prices are combined to evaluate treatment effects. For example, Tully et al. (1985) evaluated treatment effects during grazing trials by estimating net output value. Actual output can be determined on a per flock basis or per unit of investment. Tully suggested that the output per flock is more important to the farmer because the level of investment is usually low. Cost/benefit analysis has also been used for OFLR (Sidahmed et al., 1985). Marginal rates of returns are compared to the incremental costs of production in order to evaluate economically promising treatments. However, the analysis is based on minor changes in the system and fails to consider the interrelationships between resources, nutrition, health, etc. (Sidahmed et al., 1985). Whole system modeling is often suggested to evaluate such interrelationships. But modeling may not return costs in time and effort (Zandstra, 1985). It's recommended that modeling be done only when evaluating new production systems and not for normal research (Ahmed et al., 1985). The simulation of economic activities has been used successfully when abnormal conditions (i.e., drought) affected experimental results (Ahmed et al., 1985). Other documented methods include sensitivity analysis of price variations, time series analysis and the evaluation of the timeliness of inputs (Ahmed et al., 1985; Starkey and Apetofia, 1986).

The use of empirical data and adoption. The predictive approach, as discussed above, allows the team to logically evaluate new technologies within the farmer's environment. By collecting data under experiments conditions, the research team attempts to predict how farmers might react to a new technology. However, strict reliance on experimental data for evaluation eliminates an important component of on-farm research. Farmers' observations provide valuable input when evaluating a farming system, a new technology and the experiment (Atta-Krah, 1985; Yackout et al., 1985; Sidahmed et al., 1985; Ahmed et al., 1985; Bundersonet al., 1985). When conducting researcher managed trials, empirical data from farmers can identify problems, constraints and opportunities from farm experiences not recognized by the team. Jaeger (1984) used empirical data to evaluate effects of animal traction. A series of cross-sectional and time series observations were recorded across a sample of small farmers. Informal interviews formed the basis for collecting farmer's opinions about treatments in a study by Tully et al. (1985). It has been suggested that the best way to evaluate a technology is by allowing farmers to decide which treatments are acceptable. For example, Starkey and Apetofia (1986) suggest that the only way to assess the ability of animals to perform work through the farming season, while using resources which are available and affordable, is to use the farmer's evaluation. The absolute measures in animal traction are meaningless. Only farmers are able to judge animal performance and identify constraints. Farmers evaluated the treatment in terms of changes in survivability and weight gains. The interpretation of farmer's observations should be done with caution. Farmers develop opinions based on their own experiences and self-interests. Likewise, opinions are easily confounded when conducting trials on farmer's land (Tully et al., 1985), They may like the technology but dislike the inconvenience of conducting a trial. Before making far reaching recommendations based on empirical

data, the team must be confident that results come from a typical environment, climate and a representative group of farmers.

Besides the use of empirical data to evaluate treatments during experiments, estimates of acceptability provide an additional analysis for farmer managed trials. The rate of acceptance is a true measure of a technology's success or failure. When farmers are willing to spend their own money and time on a treatment while paying full cost, the innovation can be considered successful under the current conditions (Yackoutet al., 1985). Given the large investment in capital and labor associated with changes in livestock management, adoption of a new technology should increase confidence in the treatment's effect. An acceptability index is one method used in crop research to test adoption (Shaner et al., 1982). The index is calculated by multiplying the percentage of farmers who adopt the new technology by the percentage of the affected crops on their farm and dividing the product by 100. An index of 25 is large enough to warrant the treatment's recommendation. If crops are replaced with animals in the equation, the index may become only a percentage of adoption. Small farmers with livestock usually are unable to implement a technology on a portion of their flock or herd. Management practices or small numbers of animals will not permit partial changes. Therefore, the percentage of adopting farms is multiplied by a coefficient of 1. The index has limitations when used with livestock. An alternative might be to estimate the percentage of animals managed under the new technology within the research site. However, results derived from percentages should be evaluated carefully. For example, a 50% adoption rate by farmers is not the same as 50% of the animals. All of the adopting farms may be of one type and manage less than 10% of the animals in a region. Likewise, all of the animals utilizing the new treatment may be owned by a few farms. The acceptance of new treatments may lead to increases in animal numbers. Changes in flock or herd size could be an alternative parameter to measure acceptability. Atta-Krah (1985) measured flock size when conducting trial on free ranging sheep and goats. An increase in numbers demonstrated a successful treatment. Rate of adoption was used by Bunderson and Cook (1985). When measured over time, the analysis provides information on the perceived risk or the availability of new capital and labor.

Conclusion

After reviewing experiences from OFIR, one conclusion becomes evident. Because OFLR is relatively recent and methodologies are still developing, no clear set of guidelines exists. With such diversity and variation found at each research site, the reliability of research methodology recommendations becomes questionable. Successful farming systems research depends on the team's ability to clearly define research objectives and understand the principal concepts of systems research. Rather than follow specific guidelines, the modification of experimental procedures to "fit" the research environment and objectives will yield improved results. For example, much OFIR is oriented towards determining statistically significant differences between treatments. If much variation exists between experimental units, tests for significance are best left to on-station research. It is recommended that OFIR be limited to farmer managed trials and use measures of acceptability as test parameters. The uniqueness of each research project makes the selection of experimental methodologies an art rather than a science.

Even with such diversity, new experimental techniques can provide future research with relevant information. Therefore, publications of OFLR should include explicit descriptions of all methodologies used. Not only should

techniques in biological testing be included, but all methodologies unique to farming systems research. Sampling techniques, farmer survey methods and site selection are but a few areas which need further development. Likewise, additional study into the effectiveness of research methods is needed. Examining the success of past research remains a low priority. Yet, the improvement of methodologies comes only from evaluating past performance. The combination of increased communication between livestock researchers and the testing of research techniques will further advance the effectiveness of OFLR.

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The authors wish to thank Chris Andrew for his assistance and guidance in developing this paper and the Farming Systems Support Project for their financial support.

A QUANTITATIVE MODEL OF THE LIVESTOCK SYSTEM COMPONENT OF A BANGLADESH FARM[1]

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SUMMARY

Many good qualitative diagrams or models of farming systems are found in publications depicting the multitude of interconnections. Less common are references that give Quantitative connections between and among the various components. These interrelationships are numerous and complex, but must be better understood by the researchers in farming systems if alternative technologies are to be effectively tested for their relative value to the total system. However, to attack the total system is beyond the scope of this paper. What we have done is to focus on a simple version of the livestock component with the objective of developing a few composite parameters which might be used to study the interactions with other components of the total farming system such as the cropping pattern, the homestead, the market and others.

This paper describes an attempt by the authors to quantify the various connections within the livestock component of a traditional totally integrated Bangladesh farm. The livestock component, in this case, is defined by the direct linkage between the nutrient sources and the resulting animal products. On this medium size traditional farm of 1.2 hectares the cultivated area provides about 87% of the nutrients, while embankments, roadsides and wasteland (both on and off farm) provide the remainder. The animal products are draft power, meat, milk, eggs, manure and skin/hides from an approximate combination of one bullock, one cow with calf, one two-year—old heifer, one doe goat with twin kids, -four hens and -four ducks. The cultivated crop are which provides so much nutrients as crop residue and weeds is almost totally dependent on livestock for draft power.

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The connecting links between the nutrient sources and the animal products are each defined by quantitative values for the supply and demand relationship for dry matter, metabolizable energy and digestible protein. These numerous quantitative links are combined on each side to define a seasonal supply an demand balance. Then the use of these quantitative links to measure the interactions caused by technological changes in the cropping systems, etc. is discussed in light of how they can help us better understand the total farming system.

The parameters used for these quantitative links are only rough estimates adapted from a variety of local and international references which may or may not be most accurate. The main purpose of this paper is to demonstrate the use of the model and to encourage Livestock/FSR team members to test them and improve both the model and the parameters.

INTRODUCTION

Farming Systems Research (FSR) in Bangladesh has been initiated by the crop research institutes only in the past year, fallowing five to ten years of Cropping Systems Research (CSR). They have not included a livestock component in the CSR nor FSR for lack of trained animal scientists in these institutes. Past livestock research at the Bangladesh Agricultural University and the Directorate of Livestock Service has been essentially academic studies on the research stations rather than on-farm. The Livestock Division of the Bangladesh Agricultural Research Council (BARC) has considered the alternatives of either: 1) supporting continued specific discipline livestock station research; 2) establishment of complete model farms on the station for controlled research and modeling; or 3) encouraging FSR on traditional farms. BARC has chosen to recommend major emphasis on interdisciplinary FSR on traditional farms with backup modeling and component technology testing on the station to develop practical problem solving technologies.

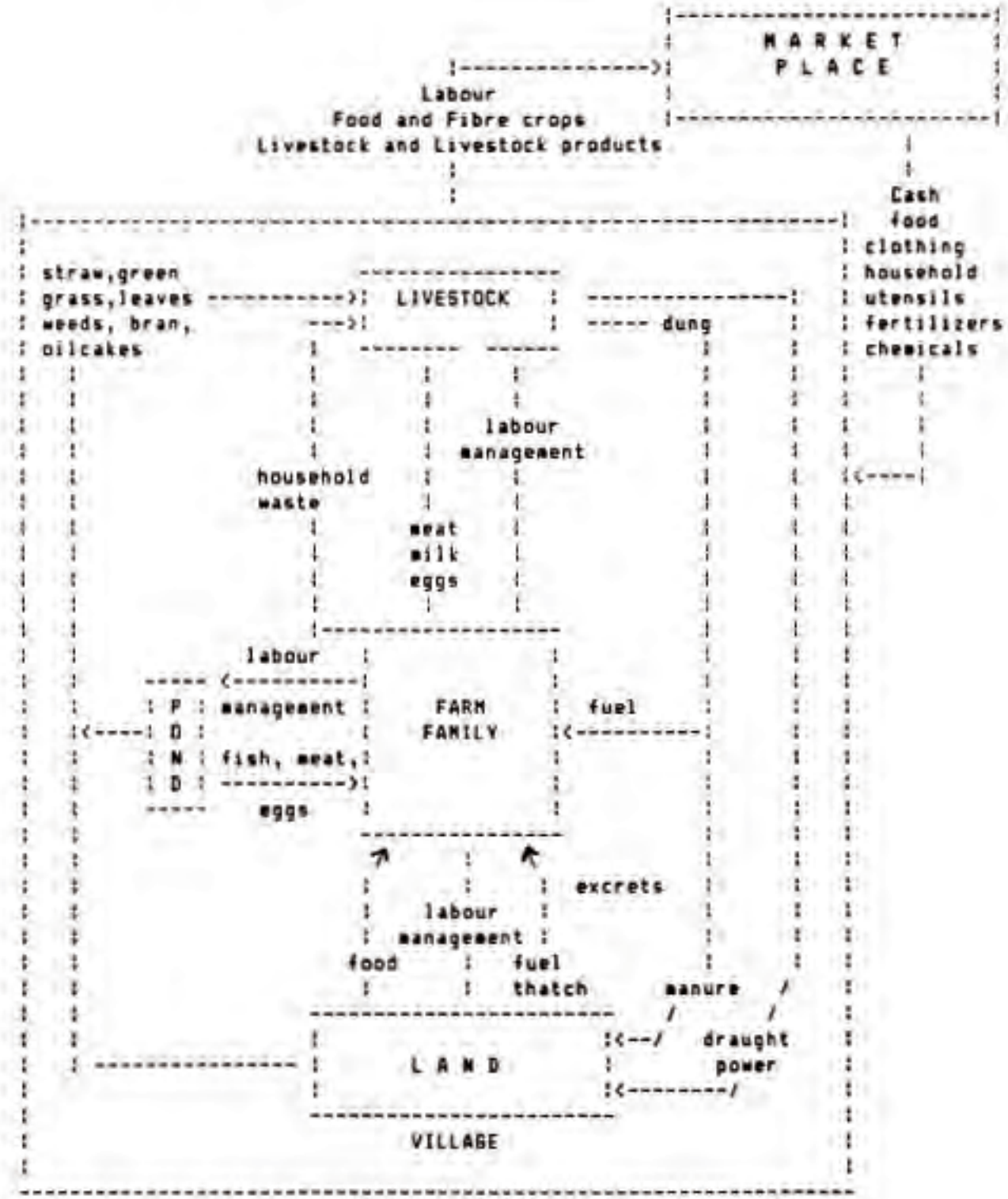
The Livestock Research Institute (LRU of Bangladesh has recently been established with the mandate to carry out these recommendations and improve the effectiveness of livestock research results for the small farmer—livestock holder. This new institute is now in the process of developing a Livestock Systems Research Division. LRI will be conducting a FSR program in cooperation with several crop research institutes having considerable experience in cropping systems research but with very little livestock systems experience, information or training (Abedin and Mallick, 1985). The limited livestock and fodder information that is available for Bangladesh is mainly of

global (macro) level (Dickey and Huque, 1986). The joint research planned by LRI and the crop institutes at 23 FSR sites will provide micro level livestock information to better understand the livestock systems and the interactions with the crapping systems. The Livestock Systems Research Division will be the major emphasis of the new LRI, with station research being a supporting part of the system. Training of scientists in livestock systems research is essential to the success of the inter-institutional FSR program. Given the dearth of livestock information, training and infrastructural development, the following description of the livestock component of the farming systems was developed as a point of reference from which to better understand the problems faced by the institute.

Numerous Bangladeshi and international publications have given good qualitative descriptions and models of Farming Systems, including both livestock and crops (Jackson et al., 1981; McDowell, 1984 and 1985; and Camoens et al., 1985). Figure I, adapted from Jackson et al. (1981), is typical of the qualitative models depicting the complex interconnections of the many components of a farming system. The art of researching these systems is also complex, involving appropriate site selection, evaluation, description, monitoring and analysis; on—station research; extension; and a continuing interaction among the farmers, the interdisciplinary FSR site team, the station researchers and the extensionist (Hildebrand, 1982; Biggs, 1983; Gibbon, 1985; and Harma, 19S4). While most FSR papers reviewed expressed the opinion that both crops and livestock should be studied together, Price and Acebedo (1983) state that "resources would probably be better spent developing crop and livestock enterprises independently". Given the total integration of the two enterprises in the traditional Bangladesh farming system, and given that independent livestock component research has been essentially ineffective for extension to small farms, the LRI Master Research Plan has been directed toward an integrated research system.

Unfortunately, very few quantitative linkages are defined in the various publications describing the livestock and crop connections. Camoens (1985) gives a quantitative description of size and composition of each component, but shows only grain and pork outputs, without quantifying the interdependence. McDowell (1985) shows how quantitative nutritional requirements and availability are affected by changes in the crapping system and by changes in the animal potential (Figure 2). McDowell demonstrates how a production increase from the change of one

Figure 1. Inter-dependence of the Livestock and Crops in the Farming System



Source: Adapted from Jackson et al. (1981)

Figure 2. Traditional vs. Improved Models for Milk Production in the Highlands of Ethiopia

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                                                          ---------------
                                                          : Requirement :
                              TRADITIONAL                 :     for     : Non-
-----------------------------------------          ---------:  1,000 kg   : viable
: Subsistence Crops  :  Cash Crops :  Native  : Avail. :    Milk:    :
:     1.7 ha         :    0.5 ha   :--------->:  4.0   :     7.0     :
-----------------------------------------   Cow    -----------------------
                                                          DRY MATTER


                                                          ---------------
                                                          : Requirement :
                              IMPROVED I                  :     for     : Non-
-----------------------------------------          ---------:  1,500 kg   : viable
: Subsistence Crops  :    Forage   : Improved : Avail. :    Milk:    :
:     1.7 ha         :    0.5 ha   :--------->:  6.5   :     8.0     :
-----------------------------------------   Cow    -----------------------
                                                          DRY MATTER


                                                          ---------------
                                                          : Requirement :
                              IMPROVED II                 :     for     :
-----------------------------------------          ---------:  1,800 kg   : Viable
:Subsistence Crops:Cash Crops:Forage:Improved : Avail. :    Milk:    :
:     1.2 ha      :   0.3 ha :0.7 ha:-------->:  8.0   :     8.0     :
-----------------------------------------   Cow    -----------------------
                                                          DRY MATTER
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Source: McDowell (1985)

factor (cow production potential) is dependent on a change in another, namely the cropping system to increase the nutrient supply. Modeling is used by Konandreas and Anderson (1982) to study the quantitative relationship between the feed supply and the animal herd composition and to predict production levels based on the supply of energy and protein from the plants available, and the demand from the particular animal composition and potential. Simplified versions of some of these methods cited will be used to better define the livestock component on the Bangladesh farm.

This paper roughly calculates quantitative nutritional linkage between farm/wasteland fodder production and animal production on a traditional Bangladesh farm. For the exercise we have used a medium size farm of 1.2 hectare having about 3.1 animal units (AU)[1] with a composition close to the average Bangladesh farm having livestock, as shown in Table 1 adapted from the 1977 Bangladesh Agricultural Census Report (BBS, 1981). It is estimated that 87% of the feedstuff comes from the farmland and 13% from embankments and wasteland. Livestock production is a sub-system of Bangladesh agriculture where per unit animal productivity is very low and at a subsistence level. Eighty seven percent of all rural households had some type of livestock in 1983-84 (BBS, 1986). Essentially all cattle, buffalo, goats, sheep, chickens and ducks are produced from backyard and small holder farms on which the small livestock producers are basically crop farmers who keep livestock to support crop production. The main purposes for keeping cattle and buffalo are to provide draft power, transport and manure, which amounts to 98% of crop cultivation and an important part of fertilizer and fuel. Often considered secondary are milk, meat and long—term saving from cattle and buffalo; periodic supplementary cash income and meat from goats; and instant petty cash or home meat and egg supply from poultry. While meat, milk and eggs are given less emphasis compared to draft power and manure, these food products are very important as a food protein source and represents 61% of the total livestock production value. It should be noted that swine are only kept by a very limited ethnic group, so are not mentioned further.

The objectives of the paper are: 1) to give a quantitative example of the livestock system inter—relationships, 2) to show what data are required for study; 3) to give alternative means of data collection (estimation); and 4) to suggest uses of the results for better study of interactions with the cropping system and other farming system components.

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[1] A.U. = 200 kg animal live weight equivalent

Table 1. Distribution of Livestock by Size of Farm in Bangladesh

Size Holding \ Species	% Holding	Cattle per Farm	Goats per Farm	Poultry per Farm	Animal Units per Farm	An.Un. per hectare	Total A. U. (000)	% of Total A. U.
0. hectare	8.7	2.28	1.54	7.9	2.0	-	1250	6.7
0.01-0.20	5.0	0.80	0.66	4.5	0.8	7.4	280	1.5
0.21-0.40	9.5	1.23	0.76	5.6	1.1	3.7	750	4.0
0.41-0.60	11.7	1.83	0.88	6.2	1.6	3.2	1320	7.1
0.61-1.00	19.3	2.42	1.04	6.9	2.0	2.5	2750	14.8
1.01-3.03	37.3	3.73	1.47	8.6	3.1	1.5	8300	44.5
3.04 Plus	8.7	7.35	2.46	12.8	6.0	1.5	3750	20.1
Aver. 1.2	100	3.1	1.3	7.8	2.6	2.2	18,600	100

Source: Adapted from BBS. (1981)

METHODOLOGY

The livestock production and feedstuff data from Bangladesh publications summarized by Dickey and Huque (1986) form the main data base for the following calculations. Seasonal variations in crop residue, green cut forage and fallow land grazing are estimated from the traditional cropping patterns and rainfall data as presented by BARC (1985). Estimates are calculated for one month (March) in the dry season and one month (September) in the rainy season. Similar estimates should be made for all months as a baseline for eventual micro data analyses. Contrary to the common assumption, the dry season provides a greater quality and quality of feedstuff for the animal population than does the rainy season (Harmans, 1984 and Tareque, 1984). This is primarily due to flooding of potential grazing areas, lower quality forage and shortage of crop residue in the rainy season. Following are the steps taken to make these estimates.

First, the feedstuff dry matter (DM) available in each month was calculated by summing the storage and current production of each feedstuff available that month. The metabolizable energy (ME) and the digestible protein (DP) available were then calculated by multiplying the DM quantity of each feedstuff by a factor unique to that feedstuff, season and nutrient (standard published factors in the absence of specific analyses).

Second, maximum DM intake was calculated based on body weight, species and estimated maximum daily intake for each animal. These were summed and multiplied by 30 days to represent an average month.

Third, the daily required ME and DP was calculated for each animal based on species, body weight, maintenance requirements, gestation status, work load, milk yield, egg yield and growth rate unique for each month based on standards presented by Kearl (1982). Animal weights and production levels for each product was assigned for each month and each animal based on Bangladesh data reviewed by Dickey and Huque (1986). The authors admit the weakness of many of these parameters, but gladly present them as a challenge to the new livestock systems researchers to improve upon through micro level research at the FSR sites.

Fourth, a diagram of the livestock/forage system showing the connections between the feedstuffs and the animal production is drawn giving the quantitative value of each connection in terms of DM, ME and DP. The percent of the nutrient demand supplied by the source is calculated for each month based on current expected production level, and then calculated for the low nutritional supply season (September) with improved animal productivity and size.

Finally, these resulting parameters are discussed in light of how they can be used to better define the interrelationships between the livestock and the crop components of the farming systems. Ways of improving the livestock and forage measurements are briefly explored. While statistical analyses are not used in this exercise, suggestions for such analyses are discussed for future use.

DISCUSSION

Before preliminary introduction and testing of new technologies on the farm one should have the traditional system as well defined as possible. Following new technology introductions the process of monitoring the production system will provide data for both testing the new technology and better defining the total farming systems. The calculations and parameters presented and discussed in the subsequent pages are our first efforts to quantitatively define the interconnections between this farm's livestock and its feed supply in terms of DM, ME and DP. The future livestock system researchers of LRI and their crop institute counterparts on the FSR site teams are challenged to improved and correct these estimates. Collection of good monthly on—farm data over the next few years of monitoring livestock and crop technology interventions will increase our knowledge of the traditional farm, provide evaluation of introduced technology and identify potentials for new station research and new introductions.

Nutrient Supply

The amounts of feedstuff DM estimated to be available from this 1.2 hectare farm for March and September are presented, respectively, in Tables 2 and 3. The component estimates for each crop are reduced to the farm level from national production statistics and assumed crop residue—grain ratios. These weak estimates should be replaced with actual on—farm forage and crop residue yield data from the FSR sites as soon as possible. First, the amount of stored feed (rice straw in this case) is

Table 2. Availability of nutrient Dry matter (DM) from a Traditional Bangladesh Farm of 1.2 hectares for the Month of March.

[(Storage 1st Mar./Months to next harvest)	– Fuel etc.]	x % DM	=	Stored Straw DM Available
[(440 kg Straw/3 months)	- 00]	x 90%	=	132 kg
(Mar. Straw Harvest	- Fuel etc.)	x % DM	=	Fresh Straw DM Available
(34 kg	- 12)	x 85%	=	19 kg
Mar. Pulse Hay Harvest		x % DM	=	Pulse hay Dm Available
26 kg		x 90%	=	23 kg
Mar. Weeds (Cropland)		x % DM	=	Weeds DM Available
500 kg		x 20%	=	43 kg
Mar. Green Cut (Wasteland)[1]		x % DM	=	Green Cut DM Available
215 kg		x 20%	=	43 kg
Grazing hrs/All[2] x kg Grazed/hr	x AU's x 30 days	x % DM	=	Grazing DM Available
4 hrs. x 2.0 kg	x 3.0 AU's x 30 days	x 20 days	=	144 kg
Mar. By product concentrates		x % DM	=	By product DM Available
26 kg		x 90%	=	23kg
Mar. Scavenger		x % DM	=	Scavenger DM Available
46 kg		x 50%	=	23 kg (75% of Poultry Requirement
Total DM Available for March			=	450 kg DM

[1] It is arbitrarily assumed that 25% of green is cut and 75% grazed in the rainy season.

[2] AU = 200 kg Animal Live weight Equivalent

Table 3. Availability of nutrient Dry matter (DM) from a Traditional Bangladesh Farm of 1.2 hectares for the Month of September.

[(Storage 1st Sept./Months to next harvest)	- Fuel etc.]	x % DM	=	Stored Straw DM Available
[(288 kg Straw/3 months)	- 0]	x 90%	=	86 kg
(Sept. Straw Harvest	- Fuel etc.)	x % DM	=	Fresh Straw DM Available
(0 kg	- 0)	x 85%	=	0 kg
Sept. Pulse Hay Harvest		x % DM	=	Pulse hay Dm Available
0 kg		x 90%	=	0 kg
Sept. Weeds (Cropland)		x % DM	=	Weeds DM Available
500 kg		x 20%	=	100 kg
Sept. Green Cut (Wasteland)[1]		x % DM	=	Green Cut DM Available
320 kg		x 20%	=	64kg
Grazing hrs/All[2] x kg Grazed/hr	x AU's x 30 days	x % DM	=	Grazing DM Available
2 hrs. x 2.0 kg	x 3.0 AU's x 30 days	x 20 days	=	72 kg
Sept. By product concentrates		x % DM	=	By product DM Available
26 kg		x 90%	=	23kg
Sept. Scavenger		x % DM	=	Scavenger DM Available
46 kg		x 50%	=	23 kg (75% of Poultry Requirement
Total DM Available for September			=	368 kg DM

[1] It is arbitrarily assumed that 75% of green is cut and 25% grazed in the rainy season.

[2] AU = 200 kg Animal Live weight Equivalent

determined by one of several methods (weight at harvest, weight currently, measure stack volume and covert to weight); divide by the number of months it must be used before new straw harvest; subtract amount used for fuel, building, etc.; and multiple by the assumed DM content (B5 to 90%) to obtain the availability of stored rice straw DM for a particular month. Next, the fresh straw harvested and fed or used otherwise would be subjected to the same measurements and calculations, given only one month to be fed and approximately 85% DM. Mow, the weeds cut from the crops and the green grass cut from embankments and wasteland can be weighed initially with small hand held spring scales to determine average weight contained in commonly used containers, then subsequent measures can be by container of specific type green forage. The green forage grazed is obtained by recording the hours grazed by each animal and assuming a green matter consumption of 2 kg per hour per animal unit (in the absence of local grazing trials). All green forage is assumed to have a DM content of 20% for calculation of DM availability. The concentrates can be weighed with small spring scale as it is obtained either from homestead milling or from the market, and also weighed or measured as fed to each class of animal. Concentrate DM content is assumed to be 90%. The scavenger material feedstuff is an assumed figure to complete poultry requirements assuming that the poultry are allotted only one third of the available concentrates. That is, we will assumed that other animal species get two thirds of the concentrates and poultry must scavenger for the rest of their needs, which amounts to about 75% of the poultry requirements. The resulting estimates of available DM for March and September are 450 kg and 368 kg, respectively.

The ME and DP availability estimates for March and September are presented, respectively, in Tables 4 to 7. These estimates are the product of the kilograms of DM available multiplied by the mega calories (Mcal) of ME/kilogram DM for metabolizable energy and by percent DP for digestible protein (Kearl, 1982). These factors vary from one type feedstuff to the other as well as from season to season. However, in this example only the DP is varied from March to September because DP is believed to be affected most by the great difference in grazing area available which, in turn, limits selective grazing in the rainy season. The totals available for each nutrient are as follows: 865 and 709 Mcal ME for March and September, respectively; and 27.0 and 16.0 kg DP for March and September, respectively.

Table 4. Metabolizable Energy Available Monthly from a 1.2 Hectare Bangladesh Farm in March[1]

Nutrient / Feedstuff	Dry matter Available (kg)	M.E. Mcal/kg	Total Available M.E. (Mcal)
Straw	151	1.68	254
Pulse hay	24	1.97	47
Green Cut Grass/Weeds	85	1.79	152
Grazed Grass	144	1.97	284
Concentrates	23	2.8	64
Scavenger Feed	23	2.8	64
TOTAL	450	1.9	865

Table 5. Metabolize Energy Available Monthly from a 1.2 hectare Bangladesh farm in September

Nutrient / Feedstuff	Dry matter Available (kg)	M.E. Mcal/kg	Total Available M.E. (Mcal)
Straw	86	1.68	145
Pulse hay	0	1.97	0
Green Cut Grass/Weeds	164	1.79	294
Grazed Grass	72	1.97	142
Concentrates	23	2.8	64
Scavenger Feed	23	2.8	64
TOTAL	368	1.9	709

[1] The average farm population of 3.1 A.U. requires approximately 745 Mcal Metabolizable Energy (ME) per month.

Table 6. Digestible Protein Available Monthly from a 1.2 Hectare Bangladesh Farm in March[1]

Nutrient / Feedstuff	Dry matter Available (kg)	Percent DP	Total Available DP (kg)
Straw	151	0.33	0.6
Pulse hay	24	6.67	1.6
Green Cut Grass/Weeds	85	4.44	3.8
Grazed Grass	144	8.89	16.0
Concentrates	23	11.11	2.6
Scavenger Feed	23	11.11	2.6
TOTAL	450	5.89	27.0

Table 5. Digestible Protein Available Monthly from a 1.2 hectare Bangladesh farm in September

Nutrient / Feedstuff	Dry matter Available (kg)	Percent DP	Total Available DP (kg)
Straw	86	0.33	0.3
Pulse hay	0	6.67	0
Green Cut Grass/Weeds	164	4.44	7.3
Grazed Grass	72	4.44	3.2
Concentrates	23	11.11	2.6
Scavenger Feed	23	11.11	2.6
TOTAL	368	4.35	16.0

[1] The average farm population of 3.1 A.U. requires approximately 745 Mcal Metabolizable Energy (ME) per month.

Nutrient Demand

Table 8 shows the formula for calculating maximum DM intake. Dry matter intake is calculated separately for each animal based on body weight and estimated percent of body weight which that animal can normally consume daily. Me use 2.0 to 2.5% for large ruminants, 3.5% for small ruminants and 10% for poultry (chickens and ducks). The limits on DM intake are important because some high fiber feedstuffs are so low in energy and protein content that the animal can not consume enough to meet his energy and protein requirements regardless of the amount of DM available. Dry matter intake may be higher for some Bangladesh livestock, especially younger ones (Saadullah, Haque and Dolberg, 1980 and Harmans, 1984). However, given the poor quality forage available and low animal productivity level (which both limit intake) the lower estimates are used. These calculations indicate that the maximum DM intake is 13.6 to 16.6 kg per day or 408 to 497 kg per month.

It should be noted that ruminants can use forage to supply up to 100% of their ration, while poultry need a very high quality ration of concentrate or selected scavenger materials. It is arbitrarily assumed that 75% of the poultry needs come from scavengering and 25% from concentrates. These ration restrictions limit the number of poultry which can be maintained due to the low availability of concentrates and scavenger materials.

Now we look at the minimum requirements of ME and DP to maintain the animals of given weight and productivity level/status. Tables 9 to 12 give the sample calculations as they vary from one weight to another on the same animal and as they vary with pregnancy status, work load, milk yield and rate of gain. The individual animal needs are calculated in terms of daily requirements; summed for both ruminants and poultry, and then summed as a grand total daily requirement. The requirements for ruminants and for poultry are totaled separately to facilitate verification that sufficient high quality concentrate feed is available for the poultry needs. Finally, the grand total daily requirements are converted to monthly needs by multiplying by 50 days. The resulting estimated monthly requirements for all animals on the 1.2 hectare farm for March and September are 900 Mcal ME and 735 Mcal ME, respectively; and 26.22 kg DP and 16.35 kg DP, respectively.

Table 8. Maximum Daily and Monthly Intake of Feedstuff Dry Matter (DM) for all Animals (3.1 Animal Units) on a Typical Bangladesh Farm of 1.2 Hectares

Large Ruminants (1 Bullock, 1 Cow, 1 Calf and 1 Two-Year-Old Heifer)

Bullock Body Weight	x % DM Intake	=	Bullock DM Intake
250 kg	x 2.0% to 2.5%	=	5.00 to 6.25 kg
Cow Body weight	x % DM Intake	=	Cow DM Intake
200 kg	x 2.0% to 2.5%	=	4.00 to 5.0 kg
2-yr-old Heifer Body Weight	x % DM Intake	=	Heifer DM Intake
100kg	x 2.0% to 2.5%	=	2.0 to 2.5 kg
Calf Body Weight	x % DM Intake	=	Calf DM Intake
35 kg	x 2.0% to 2.5%	=	0.7 to 0.9 kg

Small Ruminants (1 Doe and 2 kids)

One Doe Body Weight	x % DM Intake	=	Doe DM Intake
20 kg	x 3.5%	=	0.7 kg
Two kids Body Weight	x % DM Intake	=	Kid DM Intake
6 kg	x 3.5%	=	0.2 kg
		=	12.6 to 15.55 kg

Ruminant DM Intake Sub Total

Forage can supply 100% if necessary

Poultry (4 Chickens and 4 Ducks)

Four Hens Body Weight	x % DM Intake	=	4 Hens DM Intake
4 kg	x 10%	=	0.4 kg
Four duck Body Weight	x % DM Intake	=	4 Ducks DM Intake
6 kg	x 10%	=	0.6 kg
		=	1.0 kg

Poultry DM Intake Sub Total

(Minimum 25% concentrate and remainder Scavenger Material)

Total Daily Maximum DM Intake	=	13.6 to 16.55 kg
x 30 days =		
Total Monthly Maximum DM Intake	=	408 to 497 kg

Table 9. Daily and Monthly Metabolizable Energy (ME) Required for all Animals Units from a Typical 1.2 Hectare Bangladesh Farm at March Production Level[1]

Large Ruminants (1 Bullock, 1 Cow, 1 Calf and 1 Two-Year-Old Heifer)

Bullock 250 kg	6.25 Mcal ME Maintenance	+ 2.4 Mcal ME 4 hrs work/day	+ 0.95 Mcal ME 125 gm Daily Gain (DG)	= 9.60 Mcal ME
Plus: Cow 200 kg	5.46 Mcal ME Maintenance	+ 0.0 Mcal ME Non Gestation	+ 1.9 Mcal ME 4 hrs work/day	
		+ 3.3 Mcal ME 3.0 lts Milk Yield/(MY)/day	+ 0.0 Mcal ME 0.0 DG	= 10.66 Mcal ME
Plus: Heifer 2-yr 100 kg	3.25 Mcal ME Maintenance	+ 0.45 Mcal ME 2 hrs work/day	+ 0.9 Mcal ME 250 gm DG	= 4.6 Mcal ME
Plus: Calf 3-mos 35 kg	1.3 Mcal ME Maintenance	+ 0.35 Mcal ME 250 gm DG	- 1.65 Mcal ME 1.5 lts Milk Intake/day	= 0.0 Mcal ME

Small Ruminants (One Doe and Two kids)

One Doe 20 kg	0.98 Mcal ME Maintenance and Gestation	+ 0.09 Mcal ME 25 gm DG	+ 1.25 Mcal ME 1.0 lt MY/Day	= 2.3 Mcal ME
Plus: Two Kids 6 kg	0.42 Mcal ME Maintenance	+ 0.17 Mcal ME 25 gm DG each	- 0.63 Mcal ME 0.5 lt Milk Intake/day	= 0.0 Mcal ME

Total Daily ME Requirement for all Ruminants (Forage can supple 100% if necessary)				= 27.16 Mcal ME

Poultry (four chickens and four Ducks)

Four Hens 4 kg	ME Maintenance	+ ME Gain	+ ME Egg Production	= 1.14 Mcal ME
Plus: Four Ducks 6 kg	ME Maintenance	+ ME Gain	+ ME Egg Production	= 1.71 Mcal ME

Total Daily ME Requirement for all Poultry (Minimum 25% concentrate and remainder Scavenger material				= 2.85 Mcal ME
				==========

Grand Total Daily ME Requirement for all Farm Animals (3.1 A.U.) = 30.0 Mcal ME

x 30 = days =

Grand Total Monthly ME Requirement for all Farm Animals (3.1 A.U.) = 900 Mcal ME

Footnote: [1] Estimates adapted from Kearl (1982) using half of reported requirement for animal of double the Bangladesh animal weight to compensate for maturity of these small breeds.

Table 10. Daily and Monthly Metabolizable Energy (ME) Required for all Animals (3.1 Animal Units) from a Typical 1.2 Hectare Bangladesh Farm at March Production Level[1]

Large Ruminants (1 Bullock, 1 Cow, 1 Calf and 1 Two-Year-Old Heifer)

Bullock 225 kg	5.63 Mcal ME Maintenance	+ 1.1 Mcal ME 2 hrs work/day	- 0.95 Mcal ME 125 gm Daily Gain (DG)	= 5.78 Mcal ME
Plus: Cow 175 kg	4.78 Mcal ME Maintenance	+ 2.24 Mcal ME Last 3 mos Gestation	+ 0.83 Mcal ME 2 hrs work/day	
		+ 1.1 Mcal ME 1.0 lt Milk Yield/(MY)/ day	- 0.95 Mcal ME 1.25 gm DL	= 8.00 Mcal ME
Plus: Heifer 2-yr 125 kg	4.06 Mcal ME Maintenance	+ 0.30 Mcal ME 1 hr work/day	+ 0.0 Mcal ME 0.0 gm Daily Gain (DG)	= 4.36 Mcal ME
Plus: Calf 9-mos 60 kg	2.23 Mcal ME Maintenance	+ 0.0 Mcal ME 0.0 gm DG	- 0.55 Mcal ME 0.5 lts Milk Intake/day	= 1.68 Mcal ME

Small Ruminants (One Doe and Two kids)

One Doe 20 kg	0.98 Mcal ME Maintenance and Gestation	+ 0.0 Mcal ME 0.0 gm DG	+ 0.0 Mcal ME 0.0 lt Milk yield/day	= 0.98 Mcal ME
Plus: Two Kids 15 kg	0.67 Mcal ME Maintenance	+ 0.17 Mcal ME 25 gm DG each	- 0.0 Mcal ME 0.5 lt Milk Intake/day	= 0.84 Mcal ME

Total Daily ME Requirement for all Ruminants (Forage can supple 100% if necessary)				= 21.64 Mcal ME

Poultry (Four Chickens and Four Ducks)

Four Hens 4 kg	ME Maintenance	+ ME Gain	+ ME Egg Production	= 1.14 Mcal ME
Plus: Four Ducks 6 kg	ME Maintenance	+ ME Gain	+ ME Egg Production	= 1.71 Mcal ME

Total Daily ME Requirement for all Poultry (Minimum 25% concentrate and remainder Scavenger material				= 2.85 Mcal ME
				==========
Grand Total Daily ME Requirement for all Farm Animals				= 24.5 Mcal ME
x 30 = days =				
Grand Total Monthly ME Requirement for all Farm Animals				= 735 Mcal ME

Footnote: [1] Estimates adapted from Kearl (1982) using half of reported requirement for animal of double the Bangladesh animal weight to compensate for maturity of these small breeds.

Table 11. Daily and Monthly Digestable Protein (DP) Required for all Animals (3.1 Animal Units) from a Typical 1.2 Hectare Bangladesh Farm at March Production Level[1]

Large Ruminants (1 Bullock, 1 Cow, 1 Calf and 1 Two-Year-Old Heifer)

Bullock 250 kg	151 gm DP Maintenance	+ 15 gm DP 4 hrs work/day	+ 47 gm DP 125 gm Daily Gain (DG)	= 213 gm DP
Plus:				
Cow 200 kg	128 gm DP Maintenance	+ 0.0 gm DP Non-gestation	+ 14 gm DP 4 hrs work/day	
		+ 165 gm DP 3.0 lts Milk Yield/(MY)/ day	+ 0.0 gm DP 0.0 gm DG	= 307 gm DP
Plus:				
Heifer 2-yr 100 kg	79 gm DP Maintenance	+ 4 gm DP 2 hrs work/day	+ 73 gm DG 250 gm DG	= 156 gm DP
Plus:				
Calf 3-mos 35 kg	33 gm DP Maintenance	+ 40 gm DP 250 gm DG	- 83 gm DP 0.5 lts Milk Intake/day	= 0.0 gm DP

Small Ruminants (One Doe and Two kids)

One Doe 20 kg	24 gm DP Maintenance and Gestation	+ 3 gm DP 25 gm DG	+ 51 gm DP 1.0 lt Milk yield/day	= 78 gm DP
Plus:				
Two Kids 6 kg	12 gm DP Maintenance	+ 12 gm DP 25 gm DG each	- 25 gm DP 0.5 lt Milk Intake/day	= 0.0 gm DP

Total Daily ME Requirement for all Ruminants (Forage can supple 100% if necessary)				= 754 gm DP

Poultry (Four Chickens and Four Ducks)

Four Hens 4 kg	DP Maintenance	+ DP Gain	+ DP Egg Production	= 48 gm DP
Plus:				
Four Ducks 6 kg	DP Maintenance	+ DP Gain	+ DP Egg Production	= 72 gm DP

Total Daily ME Requirement for all Poultry (Minimum 25% concentrate and remainder Scavenger material				= 120 gm
				==========
Grand Total Daily ME Requirement for all Farm Animals				= 874 gm DP
		x 30 = days =		
Grand Total Monthly ME Requirement for all Farm Animals				= 26,220 gm DP

Footnote: [1] Estimates adapted from Kearl (1982) using half of reported requirement for animal of double the Bangladesh animal weight to compensate for maturity of these small breeds.

Table 12. Daily and Monthly Digestable Protein (DP) Required for all Animals (3.1 Animal Units) from a Typical 1.2 Hectare Bangladesh Farm at September Production Level[1]

Large Ruminants (1 Bullock, 1 Cow, 1 Calf and 1 Two-Year-Old Heifer)

Bullock 225 kg	136 gm DP Maintenance	+ 7 gm DP 2 hrs work/day	+ 47 gm DP 125 gm Daily Gain (DG)	= 96 gm DP
Plus: Cow 175 kg	119 gm DP Maintenance	+ 24 gm DP Last 3 mos Generation	+ 7 gm DP 2 hrs work/day	
		+ 55 gm DP 1.0 lts Milk Yield/(MY)/ day	- 47 gm DP 125 gm DG	= 158 gm DP
Plus: Heifer 2-yr 125 kg	99 gm DP Maintenance	+ 2 gm DP 1 hr work/day	+ 0.0 gm DG 0.0 gm DG	= 101 gm DP
Plus: Calf 9-mos 60 kg	49 gm DP Maintenance	+ 0.0 gm DP 0.0 gm DG	- 28 gm DP 0.5 lts Milk Intake/day	= 21 gm DP

Small Ruminants (One Doe and Two kids)

One Doe 20 kg	24 gm DP Maintenance and Gestation	+ 0 gm DP 0.0 gm DG	+ 0.0 gm DP 0.0 lt Milk yield/day	= 24 gm DP
Plus: Two Kids 15 kg	23 gm DP Maintenance	+ 2 gm DP 25 gm DG each	- 0.0 gm DP 0.0 lt Milk Intake/day	= 25 gm DP

Total Daily ME Requirement for all Ruminants (Forage can supple 100% if necessary)				= 425 gm DP

Poultry (Four Chickens and Four Ducks)

Four Hens 4 kg	DP Maintenance	+ DP Gain	+ DP Egg Production	= 48 gm DP
Plus: Four Ducks 6 kg	DP Maintenance	+ DP Gain	+ DP Egg Production	= 72 gm DP

Total Daily ME Requirement for all Poultry (Minimum 25% concentrate and remainder Scavenger material				= 120 gm
				==========

Grand Total Daily ME Requirement for all Farm Animals = 545 gm DP

x 30 = days =

Grand Total Monthly ME Requirement for all Farm Animals = 16,350 gm DP

Footnote: [1] Estimates adapted from Kearl (19820 using half of reported requirement for animal weight to compensate for maturity of these small breeds.

One will observe that in some of the formulas there are Minus factors for nutritional needs from the farm source. It should be understand that when an animal's maintenance and production needs are greater than the external supply, the animal will draw from its body reserve and therefore, lose weight. The other case of a minus factor is when cows milk is provided directly to the calf. When nutrient supply is less than the demand, production priorities come into play. The animal survival mechanism will first reduce weight gain (which for females also reduces ovulation and conception), then milk yield is reduced, leaving available nutrients for the survival priority of body and gestation maintenance. Management also sets a rather high priority on work load which in turn often reduces weight, milk yield and even maintenance of life. Conversely, on the positive side, added nutrients will be used in the following order: 1) to maintain the body and gestation; 2) to support work if imposed by management; 3) to produce milk; and then 4) to gain weight and promote ovulation/conception.

Balance of Nutrient Supply and Demand

The nutritional measures DM, ME and DP presented in the previous tables are summarized in Figures 3, 4 and 5 in the form of a system model connecting the nutrient sources with the production outputs. The production outputs are not to be confused with off take which are the summation of the monthly outputs of positive and negative values. For each month and production level the balance between demand and supply is given as a percentage of the demand that is met by the supply. As you can see in Figure 3 for the month of March the animal production level is relatively high which in turn demands a high level of nutrients. Of course we find that the supply of these nutrients is also high in March which is the main cause of the higher animal production. For the month of March the farm livestock model shows that 100% of the DM, 96% of the ME and 104% of the DP are available to maintain this high level animal production. For all practical purposes that is a good balance.

Figure 3. Quantitative Nutritional Pathway Between Livestock and Fodder within a Bangladesh Farm System for the Month of March.

	(No future value) Gestation	(300 hrs) Draft	(60 lts) Net Milk[2]	(27.0 kg) Growth	(23 eggs) Eggs	(225 kg DM) Manure	(Skins, etc.) By-products
DM[1]	0.00	71	34	48	7.5	-	-
ME	0.00	142.5	68.1	95.2	21.3	-	-
DP	0.00	1.0	3.24	46.15	0.90		-

Production

DM 275
ME 529.8
DP 13.1

Ruminant Maintenance, plus Milk Factor 0.3 DP

Livestock

Polutry[3] Maintenance

DE 15
ME 42.8
DP 1.8

DM 451
ME 900
DP 26.2

Mortality
Morbidity

Nutrient Demand

DM 100%
ME 96%
DP 104%

Nutrient Demand Supplied

Nutrient Supply

DM 451
ME 866
DP 27.2

Loss from Fuel and Building etc.

	Straw	Hay	Weeds	Green Cut	Grazing	Concentrates	Scavengering
DM	151	24	43	43	144	23	23
ME	254	47	76	76	284	64.4	64.4
DP	0.6	1.6	1.9	1.9	16.0	2.6	2.6

Crop area X yield less waste other use (Fuel and Building)

Fallow land, Embankments Wasteland, Roadsides

Milling By-products

Harvest Waste, Households waste Leaves, seeds, Fruit, roots and Insects

Footnotes:

1. DM = Dry Matter in Kilograms; ME = Metabolizable Energy in Mcal; and DP = Digestible Protein in Kilogram
2. Wet Mith = Dam Milk Yield – Offspring Milk Intake = Milk Off take
3. Poultry numbers limited by availability of concentrates. It is arbitrarily assumed that 75% of requirement is met by scavengering and only 25% by concentrates.

Figure 4. Quantitative Nutritional Pathway Between Livestock and Fodder within a Bangladesh Fara System for the Month of September.

	(Future Calf Value) Gestation[1]	(150 hrs) Draf	(30 lts.) Net Milk[2]	(-0.8 kg) Growth	(23 eggs) Eggs	(184 kg DM) Manure	(Skins, etc.) By-products
DM	35	35	9	-16	7.5	-	-
ME	67.2	66.9	16.5	-30.5	21.3	-	-
DP	0.7	0.5	0.9	1.9	0.9		-

Production

:

DM 283 Ruminant Livestock Poultry[3] DE 15

ME 550.5 Maintenance : Maintenance ME 42.8

DP 13.5 : DP 1.8

:

DM 368 : Mortality

ME 735 : Morbidity

DP 16.4 :

:

Nutrient Demand

:

DM 100%

ME 96% Nutrient Demand Supplied

DP 98%

:

Nutrient Supply

:

DM 368 : Loss from

ME 709 : Fuel, Building,

DP 16.0 : etc.

:

	Straw	Hay	Weeds	Green Cut	Grazing	Concentrates	Scavengering
DM	151	24	4	4	144	2	2
ME	254	47	76	76	284	64.4	64.4
DP	0.6	1.	1.9	1.9	16.0	2.6	2.6

Crop area % yield less waste other use (Fuel and Building)

Fallow land, Embankments Waste land, Roadsides

Milling By-products

Harvest Waste, Households Waste, leaves, seeds, Fruit, Roots and Insects

Footnote:
1. DM = Dry matter in kilograms; ME = Metabolizable Energy in Mcal; and Dp = Digestable Protein in Kilograms
2. Wet milk = Dam milk yield – Offspring Milk Intake = Milk Offtake
3. Poultry numbers limited by availability of concentrates. It is arbitrarily assumed that 75% of requirement is met by scavengering and only 25% by concentrates.

Figure 5. Quantitative Nutritional Pathway Between Livestock and Fodder Given the Low Bangladesh September Feed Supply, Increase Animal Productivity and Larger Animals

	(Future Calf value) Gestation	(300 hrs) Draft	(60 lts) Net Milk[2]	(27.0 kg) Growth	(23 eggs) Eggs	(245 kg DM) Manure	(Skins, etc.) By-products
DM[1]	34	69	34	48	7.5	-	-
ME	67.2	142.5	68.2	95.2	21.3	-	-
DP	1.6	1.0	3.24	6.15	0.90		-

Production

DM 283
ME 550.5
DP 13.5

Ruminant Maintenance, plus Milk ----------Livestock---------- Polutry[3] Maintenance

DE 15
ME 42.8
DP 1.8

DM 491
ME 988
DP 28.2

Mortality
Morbidity

Nutrient Demand

DM 75%
ME 72%
DP 57%

Nutrient Demand Supplied

Nutrient Supply

DM 368
ME 709
DP 16.0

Loss from Fuel and Building etc.

	Straw	Hay	Weeds	Green Cut	Grazing	Concentrates	Scavengering
DM	86	00	100	44	72	23	23
ME	144.5	00	179.0	114.6	141.8	64.4	64.4
DP	0.3	00	1.8	2.8	3.2	2.6	2.6

Crop area X yield less waste other use (Fuel and Building)

Fallow land, Embankments Wasteland, Roadsides

Milling By-products

Harvest Waste, Households waste Leaves, seeds, Fruit, roots and Insects

Footnotes:

1. DM = Dry Matter in Kilograms; ME = Metabolizable Energy in Mcal; and DP = Digestible Protein in Kilogram
2. Wet Mith = Dam Milk Yield – Offspring Milk Intake = Milk Off take
3. Poultry numbers limited by availability of concentrates. It is arbitrarily assumed that 75% of requirement is met by scavengering and only 25% by concentrates.

Next, in Figure 4 these same connecting parameters are given for September when feed supply is low and production is also low, giving a near balance. There is a two-way cause and effect operating in these models. The weather and the crop management affects the nutrient supply, which either limits or promotes animal production. Likewise the weather and animal management affect their nutrient demand depending on total body weight, weight gain, stage and quantity of lactation, stage of gestation and hours of work. While the additional animal demand can only operate to the limit of the feed supply in quantity and quality, any additional feed supply under Bangladesh conditions can usually be used by the substantial reserve of animal production potential, especially in the rainy season.

Figure 5 demonstrates the nutrient shortage which would exist in September if animal productivity and size were increased substantially. The nutrient balance under these circumstances show that only 75% of the DM, 72% of the ME and 57% of the DP requirements would be supplied. Stated another way, to promote this higher level of animal production it would be necessary to increase the September nutrient supply by 33% for DM, 39% for ME and 75% for DP. These type parameters calculated from on—farm data to be collected by the FSR teams can be used to test various changes in cropping patterns and other interventions to meet such shortfalls.

The factors of mortality and morbidity are both to be reconciled when measuring the animal needs and production, just as forage loss to decomposition and use as fuel, building materials and compost is important to proper definition of the system.

CONCLUSIONS

This exercise has given us a quantitative description of the livestock component of a farming system in terms of the nutritional linkage between the feed sources and the animal products. Me have demonstrated how macro data (national statistics and limited socio-economic information) can be used to estimate the micro elements on the farm. These estimates are considered weak, but on the other hand they are believed to be as good as are available at this time in Bangladesh. While the quantities and qualities of the component sources of nutrients are not closely verified in these calculations, the total estimates of each nutrient DM, ME and DP are double checked. That is, they are calculated based on forage and feed available in each month and then checked against the animal needs in that month (as per maintenance and production level needs).

Next, these estimates should be verified by several means on the FSR sites by weighing and/or recording crop and crop residue yields, weed yields, green cut grass yields, grazing yield (grazing studies), purchased feed, fuel use, animal consumption, consumption waste, draft load, milk yield, egg yield, body weight, weight gain, reproductive status, mortality and morbidity. Monthly forage sample analyses would also be helpful. The limited experience of collecting on—farm livestock production and feed consumption data in Bangladesh has proven to be difficult and the data is often questionable and extremely variable. While improved data collection techniques should reduce the variability, as increased numbers will increase the confidence, the practice of using more than one method to measure and double checking the parameters is likely to remain a useful tool in FSR.

Once the livestock system component of any farming system is defined with relative confidence the FSR team will find it more useful for additional testing of new livestock technologies such as straw treatment, leucaena leaf supplements, health care and others suggested by Saadhullah (1986). Testing the secondary effects of new crop technologies, or other system changes, on the forage supply will also be facilitated.

These calculations were all done by hand to demonstrate how they can be used by the FSR site teams at the grass roots level. The more data are used to draw inferences at all levels, the more discussions will be stimulated with the site team and the farmers, thus coming ever closer to identifying problems and possible solutions. It should be noted that these formulas can also be used on available computer programs to speed the process of looking at the data in many different ways in search of new clues to improving the farmer's status.

Future statistical analyses of the monthly measurements of the variables discussed will also produce standard deviations which can help better define the probability of success of newly tested technologies before widespread extension to the farmers.

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CROP-LIVESTOCK SYSTEMS RESEARCH IN ASIA: DESIGN AND TESTING OFR

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Introduction

Evolving research methodology

In the Asian Rice Farming Systems Network (ARFSN), it was convenient to initially "ride" on the Cropping Systems Research (CSR) methodology. Such methodology evolution started with multiple cropping in early 60's. In 1974, this became multiple cropping, then cropping systems in 1979 at which time then Asian Cropping Systems Network was formed. The methodology has since developed thru consultation and interaction among collaborating scientists from national programs in the network. It consists of site selection, site description, design, testing, pre-production evaluation, and production program. A consensus to adapt the CSR into FSR was reached in the Crop-Livestock Research Workshop among network scientists at IRRI in April, 1983.

From cropping systems to farming systems

This shift from cropping systems research (CSR) towards FSR is to be done following the CSR method, either in an existing research site and intercropping livestock as an additional farm component to be investigated. Other animals and enterprises may be considered later and as the situation may warrant. In China, for instance, swine is the livestock being considered in a predominantly grains cropping systems. This step by step move, instead of considering everything in the system all at once, was deliberately done to (a) facilitate interdisciplinary effort, and (b) focus on more direct crop-livestock interdependence, e.g., use of fibrous crop residues as livestock feed, recycling animal manure for fertilizer, and utilizing animal draft power.

Smallholder farms in Asia

Importance of livestock

If India and China were included, Asia would account for roughly half the world population of 5 B. Correspondingly, 30% of 1.2 B cattle are found in Asia (Table 1.). Buffaloes are 97% of the 131 M, 29% of 1.12 B sheep and 80% of the 454 M goats.

Table 1. Distribution of Domestic Ruminants (1000 head)[a]

Area	Cattle	Buffaloes	Sheep	Goats
World	1,213,731	131,146	1,116,449	454,667
Asia	369,432	127,636	325,085	365,171
China	64,130	30,080	120,880	80,448
India	182,408	61,296	4,108	71,644
Indonesia	6,482	2,321	3,611	8,051
Japan	4,136	-	11	80
Philippines	1,983	3,037	31	1,450
Thailand	4,963	5,583	62	31
Africa	169,527	2,380	182,091	146,125
Australia	26,321	1	135,706	-
Europe	134,411	457	134,309	11,599
North and Central America	176,306	8	21,786	11,207
South America	231,751	315	197,863	18,582
USA	110,961	-	12,513	1,400
USSR	115,900	350	143,599	5,824
Developed	424,582	807	524,490	24,410
Developing	789,149	130,340	591,959	430,257
Developing, %	65	99	53	95

[a] Modified from FAO (1981) by Loosli and McDowell 1985.

Farm landholdings also continue to dwindle as they are shared by an increasing population and no rapid reduction in the proportion of farm families. So-called landless farmers, who may own some livestock and serve as hired laborers in farm work, further lower the average. In Burma, average farmers may cultivate up to 5 ha, about 4 ha in Thailand, less than 2 ha in Philippines and Indonesia, about 0.5 ha in China. The situation in China is also rapidly changing as the government implements the responsibility system. The new system basically retains the farm commune but allows farm families to cultivate a piece of land on their own.

Design consideration of on-farm trials

In designing on-farm trials that seek to improve livestock enterprise(s) of small farms, two consideration are important:

1. Integrated crop and livestock enterprises In Asia and most of the developing countries, client farms of FSR are generally small. (<1 up to 5 ha) and highly integrated. Seldom would such farmers pursue a mono-enterprise specialization. Even if he attempts to do so, his limited land and capital resources force him to maximize use of such resources and to spread risk among crops and enterprises whenever possible. Furthermore, farmers who specialize like in vegetable table growing, pig, or poultry raising, may end up in the semi-commercial to commercial scale; way out of FSR efforts.

2. Ruminant, especially large animals as entry point To gain experience in the conduct of FSR, it was also deemed wise to start with two interacting farm enterprises: crop and large ruminant. Later, when the methodology and interdisciplinary work relationships are more clear, other components of the farm may be included, like fish, pig, chickens, ducks, silkworm, etc. It is also accepted that crop and livestock interaction are more defined for the ruminants. They are more interdependent with the crops in terms of utilizing crops residues. The non-ruminants may consume some grains and brans but not the fibrous residues; they can also be fed with purchased feed.

Crop-livestock FSR

Expanding the cropping systems methodology

At the 1983 Crop-livestock workshop, it was agreed to conduct on-farm research initially in a site in five countries. Participants felt prepared to start in China, Sri Lanka, Indonesia, Thailand, and Philippines.

Design of activities was conceived along the following scheme (Fig. 1).

DESIGN ACTIVITIES

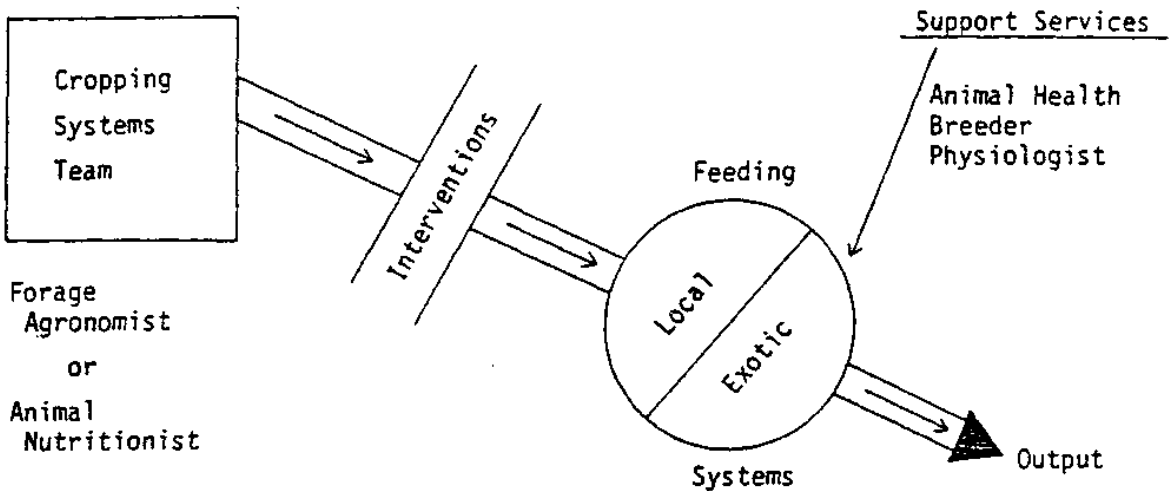

Fig. 1. Design of crop-livestock research

The cropping systems team adds a forage agronomist or animal nutritionist to review the cropping systems site. They then design a set of experiments to meet the needs of the animal feeding system. Other scientists are also involved in order to more fully understand the system. For instance, animal health problems may be assessed so that confounding effect on feeding may be accounted for.

Pre-project experience

At that time too, enough optimism was expressed as follows:

1. Some simple techniques have been used successfully elsewhere

2. Starting with few sites with livestock would make possible fielding a larger team with more evaluation capabilities.

3. Cropping systems evaluation techniques should be useful, e.g., forages or crop by-products.
4. In sites where increased feed supply is a treatment, farmers' comments on effect on animals and adoption rate will be effective if somewhat crude evaluation tool.
5. On site researchers are fairly experienced to cope with more complex data analysis.

Problem areas

In addition, problem areas were identified not only to caution research work but also to serve as methodological issues to be resolved with time. These were:

1. Ex ante analysis needed to screen technology interventions
2. Time frame for crop-livestock research much longer than for crops
3. Value of crop by-products subjective and may lead to complex budgeting problems
4. Oversimplified model evaluation may lead to inaccurate decisions
5. Cropping systems evaluation techniques may not apply to crop-livestock systems
6. Farmers may keep livestock to meet objectives other than that for crops that combined analyses may produce dubious procedures
7. On site staff relatively young with little experience to prevent complicated evaluation procedures
8. Family and animal relationships are important but no accepted analytical procedure may be available
9. Social benefits and sustainability of production must be considered but with few acceptable evaluation techniques.

Research methodology review in Year 3

On the third year of implementation, Crop-livestock researchers again held a workshop in Khon Kaen, Thailand last July, 1986. Critical evaluation of the research methodology emphasized the following points:

1. Identification of farmers; goals need to be improved so more appropriate interventions can be designed, e.g., proceeds from cattle sales partly finances crop inputs
2. Farmers' participation at all stages of FSR is important. Some ways of eliciting their participation include use of maps to identify plots. Presenting the results of initial site description to them is also useful. Then, after identifying possible interventions, researchers

should again consult the farmers. Other activities to involve farmers include field visits to station, field day, farmers' training, etc.

3. To overcome the problem of maintaining treatments throughout the experimental period, the "before and after" approach was suggested. This is in contrast to the conventional comparison between treatments. Ways of evaluating the technology include persistence, acceptability and spillover.
4. Difficulty in measuring interactions. This could be avoided by identifying them in site description, e.g., crop yield and feed availability.
5. Input from statisticians in guiding FSR researchers is encouraged. However, this could not be at the sacrifice of the objective of the trial and farmer involvement.

On-going crop-livestock systems projects

Sta. Barbara, Pangasinan

In the Philippine research system, partitioning of research activities is guided by the Philippine Council for Agriculture and Resources Research and Development (PCARRD) into program, project, and study. The study is the basic unit of activity; and several subject studies in a discipline or related disciplines make up a project. Two projects or more that interrelated make up a program. In the Philippines crop-livestock systems research project, studies are being simultaneously pursued in the following:

On-station

1. Feed technology; determination of feeding value of crop residues, by-products, and forages.
2. Pesticide residues in rice and other crops and in animals.
3. Systems analyses and simulation.

On-farm

1. Integrated crop-livestock systems
   a. Cattle fattening
   b. Water buffalo breeding (cow-calf)
   c. Backyard forages
   d. Rice and dual-purpose crops (grain + fodder)
2. Crop component
   a. Rice and dual-purpose crops (grain + fodder)
   b. Crop component technology
      1) Variety trials: rice, mung, cowpea, etc.
      2) Fertilizer trials, agronomic practices.
3. Animal health
4. Sociology and role of women
5. Pesticide residues
6. Economic analyses

One project coordinator and eight subject matter or study leaders manage the different activities, supported by four field research assistants and two research aids. Farm labor is hired as the need arises, like in obtaining and processing crop cut samples.

A research study leader may conduct both on-station and on-farm activities under one study: as in the case of the worker on pesticide residues. The project economist coordinates with the systems analyst as the latter organizes data for simulation purposes.

Project Location

The project is being conducted in 2 barangays (villages) of Sta. Barbara town, Pangasinan province, some 262 km north of Manila. Barangay Malanay represents the irrigated lowland while barangay Carosucan, rainfed lowland.

Rainfall peaks in August and starts in May or early June, then ends in late September thru October. Soil is clay loam to sandy loam with pH 6.7-7.9.

Rainfed Lowland Site

Barangay Carosucan is 6 km from town and is a rainfed area with about 142 ha; 56% of which are lowland and 44% upland. An irrigation system was built several years back but it has been inoperational due to serious salutation and lack of water. Average landholding is 1.6 ha per household.

A rice monocrop predominates, and average rice yield is 2.7 t/ha. Depending on the amount of rainfall that follows after harvest in November, some farmers may plant tomatoes, mung, peanuts, etc., but most field are left fallow.

Cattle and buffalo holdings average 1.4 per farm; or a stocking rate of 1 mature animal unit/ha (1 A.U./ha).

Farmer operators are 48 years old on the average; and a household has 5 members, 3 of whom regularly work on the farm.

Irrigated Lowland Site

Barangay Malanay consists of 118 ha, with 205 households. It has 35% land fully irrigated, 29% partially irrigated, 17% upland, and 19% rainfed. Average landholding is 1.3 ha per household.

Two rice crops are grown in the fully irrigated areas and average rice yield is 3.1 t/ha. Uplands and partially irrigated areas are planted to rice, peanut, com, cowpea, string beans, tomatoes, etc.

Cattle and buffalo holdings average 1.1/household, and 0.92 A.U./ ha stocking rate.

Farmer operators are also 48 years old on the average, households have 7 members, 4 of whom work on the farm.

Livestock Component

1. Animal Production

Farmer cooperators from each barangay were selected based on criteria from a benchmark survey of the two sites, as well as the farmer's willingness to collaborate with the research. In Malanay 20 farmers were involved, while in Carosucan, 18 farmers (Table 2.). Assignment to respective treatments was based on size of landholding and involvement in animal raising. Farmers with less than the number of animals required in the treatment group were provided with fattening cattle, on a "paiwi" sharing[3] system. This was to equalize animal holdings within treatment.

Interventions or technology package in livestock management include daily feeding with 2 kg Luecaena or other legume forages, provision of urea-molasses-mineral blocks, establishment of improved forages in lots and animal health care. Utilization of fibrous crop residues, especially rice straw, was recorded and related with actual farm grain and residue output.

The animals of the farmers were weighed during the start of the experiment, and every 1 1/2 months thereafter.

Table 2. Experimental treatments, crop-livestock

Treatments	No.of Cooperators	Farm Area ha	Livestock (No. of Draft+ Fattener)
Barangay Malanay (Irrigated)			
I + Technology	6	0.5 - 2	1 + 1
II + Technology	5	2.1 - 3.5	1 + 2
III Control	4	0.5 - 2	1 + 1
IV Control	4	2.1 - 3.5	1 + 2
Barangay Carosucan (Rainfed)			
I + Technology	4	0.5 - 1	1 + 0
II + Technology	5	1.1 - 2	1 + 1
III Control	5	0.5 - 1	1 + 0
IV Control	5	1.1 - 2	1 + 1

*Technology = package of interventions; a) daily Luecaena or legume feeding, b) salt + urea + molasses + mineral supplement, c) improved fodder supply thru legume crop residues and forage in homelots, and 4) animal health care.

Cattle liveweight gains

After 300 days feeding period, liveweight gains of cattle, apparently do not reflect differences due to farm size or interventions (Table 3.). This is especially so in Carosucan, wherein animals gained the least (0.1 kg/day). In Malanay, overall performance of animals was more uniform than in Carosucan. Control animals (Treatment III and IV) were however gaining as much if not more weight than in the intervention groups (I and II). Animals consist of those owned by farmers and contributed by the project; and were not all fed to start at the same time. Disposal of Malanay project animals was completed in October, 1985.

Table 3. Liveweight gains of fattening cattle

	Treatment	No. of Animals	Live weight		
			Initial	Final	ADG*
Malanay	I	7	279	335	0.20
	II	3	280	335	0.21
	III	3	250	303	0.22
	IV	2	293	341	0.23
Carosucan	I	4	214	272	0.18
	II	7	238	284	0.16
	III	3	174	244	0.22
	IV	5	226	278	0.17

*Average Daily Gain; 300 days feeding period.

Year round feed profile

One day each month, feeds offered to cattle were measured. Results of this feeding profile is summarized for the whole year, and average daily feed offered to cattle were (kg as fed):

Rice straw	5.6
Weeds	7.4
Leucaena leaves	0.4
Com stover	0.1
Rice bran	0.2
Salt	0.01
Total	13.80

When the above values were transformed into dry matter (DM), daily crude protein (CP) and total digestible nutrients (TDN) were 0.38 and 3.17 kg, per animal, respectively (Table 4.). Protein was apparently deficient, compared to a daily requirement of 0.53kg. Fig. 2 shows the monthly profile of feed offered.

Furthermore, the feed intake from free grazing and tethering was apparently marginal, to explain the low liveweight gains of animals. No estimates were made on feed consumed from grazing and tethering. No nutrient requirements were also added for draft use of the animals.

Table 4. Estimated crude protein and total digestible nutrients, Malanay feed offered (kg DM)

Feed	DM	CP	TDN
Rice straw	4.2	.16	1.97
Weeds	1.85	.18	1.00
Leucaena leaves	0.11	.02	0.06
Corn stover	0.08	-	-
Rice bran	0.20	.02	0.14
Total	6.44	0.38	3.17

Crop Component

1. Cropping Pattern Testing

The irrigated/upland test site in Malanay

The existing farmers pattern of planting two rice crops a year is already intensive enough, however a 70 day turnaround time between rice exist where the fields are left fallow.

Crop cut samples of the first rice crop showed about 92% of the farms planted to high yielding varieties and the rest to local cultivars. The prominent HYV's planted were the following with mean t/ha grain yield: IR42, 4.91; IR36, 3.12; IR32, 3.83; and IR54, 3.09. The farmers' local variety obtained a similar yield to IR42 (4.05 t/ha). Fresh fodder yield after harvest showed that the farmers' variety yielded highest (15.50 t/ha) followed by IR32 (15.47), IR36 (13.31). IR42 (11.42) and IR54 (11.09).

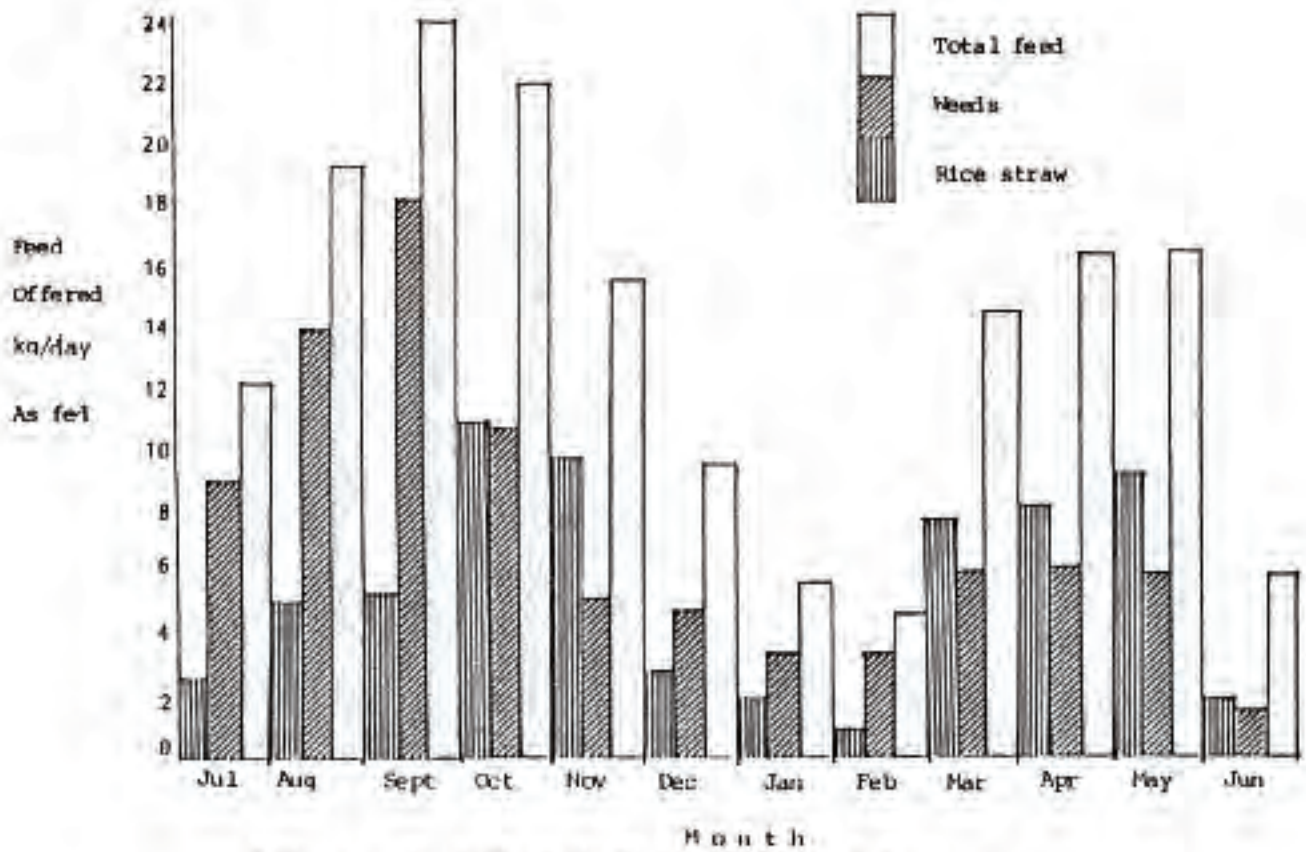

Fig. 2. Av daily feed offered to Cattle, Malanay

The rainfed test site in Carosucan

At the rainfed test site, cropping pattern trials are conducted to intensify the only rice crop the farmers are growing. Fitting in upland crops (mostly legumes) to take advantage of the residual soil moisture is the main thrust. The research team at the site further classified the rainfed site under two categories (which will be their basis to conduct cropping pattern trials). One is a medium light soil but drought-prone and the other is a heavy soil poorly drained and flood-prone. These two distinct soil textural types cover at least 40 and 60 percent of the site area respectively and majority of the rice areas in the province of Pangasinan. Farmers themselves recognize the importance of these two land types by planting early maturing HYV's (IR36) in lighter soils where water stress is expected to occur but taller and late maturing varieties (IR42, IR48 and Local) under heavier soils where flooding occurs at a time when early HVY's are at their reproductive stage and will be fully submerged if planted under flood-prone areas.

In lighter soils, transplanted early maturing rice (IR36) followed by mungbean, and cowpea was compared to rice alone which was the farmers' traditional pattern. Surprisingly, after the experimental pattern second crop establishment in zero tillage, 55% of the livestock cooperators followed mungbean and cowpea establishment under full tillage and using the local cultivars.

Grain yield in rice showed that the experimental pattern obtained and advantage of 7 and 51 percent compared to Fl and F2 farmers while only a 2 and 6 percent advantage in terms of fresh fodder yield respectively. Likewise, for mungbean and cowpea a grain yield advantage of 22% and 55% was obtained by the experimental plots compared to F2 farmers with a fodder yield potential of 3.37 and 1.75 t/ha. No fodder yield measurements were obtained from F2 farmers. Results of the two crop system showed that TFR-MG and TPR-CP in the experimental pattern over that of the Fl farmers can be accounted to an additional mungbean or cowpea yield, while that in the F2 farmers can be attributed to the higher cost in weed control and fertilizer use (60-0-0 vs. 73-0-0 for experimental and farmers practice respectively) in rice and higher yields obtained by the high yielding upland crops after rice.

Khon Kaen, Thailand

Background

The main objective was to develop a methodology on farming systems research in integration of crop and livestock enterprises of the small farmers. The research also sought to encourage collaborative research in farming systems approach. The parameters applied in measuring the tests become the specific objectives of the project i.e. cropping patterns suitable to animal production, farm by-products utilization, alternative technologies performance, farm resources efficiency and identification of constraints.

Project Components/Implementing Coordination

A. Coordination (FSRI/DOA)
1. Appointment of committees
2. Monthly and quarterly meetings
3. Financial administration
4. Progress report
5. Annual Workshop

B. Crop Component (FSRI/DOA)
1. Preliminary survey and farmers selection
2. Soil sampling and analyses
3. Site description
4. Planting, care and monitoring
5. Evaluation, analysis

C. Animal Component (DOLD)
1. Survey of public pasture
2. Animal live-weighing
3. Crop residue chemical analysis
4. Backyard forage crops monitoring
5. Crop-animal by-products monitoring
6. Animal Health

D. Socio-Economic Component
1. Baseline survey (OAE)
2. Farm-book recording and monitoring
3. Economic analysis of cropping patterns testing (OAE)
4. Rural Rapid Appraisal (KKU)
5. Evaluation of technology impact (KKU)

Methodology

Strategy

The strategy is based on the Asian Cropping Systems Methodology agreed upon in a conference held in 1983 which follows site selection, site description, design, testing multi-location testing and so on.

Design

After the preliminary survey, the cooperative farmers were selected and classified into three patterns, according to their enterprises, mode of cultivated areas and farm income, namely:

- animal-based
- crop/animal-based, and
- crop-based farming pattern

All components of research are carried out superimposed upon the three farming patterns and interrelationship is studied.

Cropping Pattern and Health

Based on the existing and typical topography of northeastern region, the cropping patterns are laid out into three types of land, i.e. upland, upper-paddy and lower-paddy.

Animal Growth and Health

Artificial insemination was introduced to the farmers to produce half-bred dairy cows of local American Brahman grade and Holstein Fresian and marketed to Dairy Promotion Organization. The male offspring are beef production and local buffaloes are also taken into consideration for monitoring.

Liveweight of animals from each cooperator farmers are recorded along with their feeding patterns. The changes in number of animals and relative reasons are being monitored. Backyard forage crops yield and crop residues along with utilization of farm yard manure are recorded and analyzed chemically. Veterinary services are given to the cooperator farmers as well as non-cooperators.

Socio-Economics Component

A base line survey was carried out to describe the existing system quantitatively. Farm records are kept to study the whole farm activities of the cooperator farmers and a nearby village. Cost and return analyses of the cropping pattern testing is also done.

Two surveys using rural rapid appraisal techniques were conducted to identify some social constraints and attitude of the farmers in aspect of farm residues utilization.

Results in Year 1

1. Cropping Patterns

Table 4 shows yield and economic return of tested patterns in two of land types. Only cropping pattern: peanut-green com gives positive return under upper paddy condition. Low crop yields in all

patterns were due to long drought (887 mm. of annual rainfall) and insects pests damage up to some extent. Moreover, the variable costs, particularly the insecticides and labour were considerably high. A crop like green corn was found to provide residue for animals of about 11.2-19.7 t/ha.

2. Animal Growth and Health

Growth rate (g/head/day) of cattle decreased from October to November onwards where the forage become inadequate. The period coincided with rice harvesting when farmers had less time to take care of their animals/ The animals were then grazed freely in the paddy field after harvesting and there were plenty of fresh rice straw resulting in increase in weight during January to February. The weights again decreased during March to April. This may be due to shortage of feeds again or it is the time of planting field crops like cassava and kenaf where farmers take less care of the animals.

Batumarta, Indonesia

Farming Profile in Batumarta Research Site

Batuca transmigration project I covering eleven settlement units with 4,50- households, was a specially designed transmigration settlement. It was gradually settled within 6 year from 1976 to 1981 This project was financed by IBRD Loan; each family receives 5 ha land instead of 2 ha, the first project with rubber tree component massive research efforts on food crops pattern, climate cattle development, soil conservation,, Imparata cylindrica (alan-alang) contril, socio-economic monitoring, and reestablishment of perennial crops.

Dry Season Component Technology Testing

Some component technology experiments were conducted during the dry season 1985 both on crops and livestock components. These are:

Livestock-Forage

1. Adaptation trial on several legume fodder crops
2. Study on the combination of grass (Setaria) and legume fodder crops for animal feeding.

Initial Site Description

Resources

The 5 ha land holding was intended for home yard (0.25), grazing (0.25) food crop land (0.75 ha), food crop land II (1.75), rubber (1) and reserved (1) for perennials. In reality it consists of 4 parcels of (0.25 + 0.75) ha, 2 ha, 1 ha of rubber and 1 ha reserved for rubber.

Animal power

This was expected to be supplied by the project. An adult cattle for each household should be repaid with one 6-9 month old calf. The first group of cattle were distributed in 1978. So far about 199 of household in the oldest unit has had a cattle while the later settlement unist such as unit VI , only 30% of households have cattle. The provision of draft cattle for transmigrant has been planned because experience shows that farmers face difficulties to cultivate all the allocated landholding.

Perennial crops

These consist of coffee, coconut, clove, kapok, rubber and fruit trees such as citrus, mango, cashew nut, banana and rambutatn. About half of the total coffee population i.e. 90,000 trees were planted in unit III, the rest are found in Unit V, VI and XI. Coconut are more evenly distributed mostly in Unit II-VII. Unit III is also ranked first for clove trees followed by Unit IV and VI. Rubber trees for unit I up to VI has been able to be tapped for about few months to about 1.5 years. So far only a small portion of perennial crops are on bearing stage.

Income

Transmigrants generate their income by implementing several economic activities to meet their need for food as well as for cash. Food crop farming is the most dominant economic activity. Other activities are tree crop, animal husbandry, off farm and non farm job.

Food crop farming

It started in house yard parcel and develop in later years to other plots. The cultivated area increase with increasing years settlement and availability of family labor as follows:

Arrival year	Household size	Labor force	Actual farm labor	Cultivated area
1976-1978	5.4	3.44	2.62	1.43
1979-1981	5.0	3.31	2.01	1.13

Perennial crops other than rubber

These could only supply small cash income between Rp 144,000 and Rp 56,000, - per year. Since 1983 there were a few settlement units where rubber parcel could be tapped already and gave net cash income between Rp 30,000 and Rp 40,000 per month. The availability of constant cash inflow every two weeks was a great help for farmers' daily life.

Planning for the crop/livestock systems research

Objectives

The main objective of the crop/livestock systems research is to improve the economic well-being of the transmigrate farmers by improving the animal and crop production systems. The primary focus will be on the various systems. The primary focus will be on the various components of these systems such as animal feed and health, varietal improvement and soil fertility and management.

The second objective of the research will be to develop strategies for increasing the cultivated area on land allocated for each transmigrate family. The third and perhaps most important objective is to develop a strategy by which these subsystems may be fitted together into profitable and manageable units recognizing that, initially at least, there will be capital and labor constraints.

Research approach

Socio economic studies

I. Compilation of standard data for ex ante analysis for each agricultural commodity that may be used in farm systems, it may consist of input-output analysis from initially up to maximum production.
II. Market studies of each commodity (locally and internationally) to get an idea of market potential of crop.
III. Baseline study of existing system
IV. Socioeconomic monitoring of existing farm systems over time to get a better idea of farm practices and constraints for:
    a. Planning purposes
    b. Evaluation of introduced technologies ever time
       Rationale: Baseline survey data becomes obsolete and must be modified.

Biological Research

I. Food Crops
    A. Component studies
       - Varietal improvement
       - Soil fertility and management
    B. Cropping systems
       - Fine tuning but basically O.K.
II. Perennial Crops
    A. Component studies
       - Methods of increasing perennial crops (other than rubber) plantation with capital and labor constraints,
       - Basic technology from Industrial/Estate Crop

B. Systems Research
- To be done and basically consider as means for land stability and cash income

III. Livestock

A. Component studies
- Animal feed
- Animal health

B. Systems
- To be done but will basically consider:
  * Large ruminants as power source.
  * Goats and sheep as source of supplementary income
  * Chickens as source of supplementary income.

IV. Mixed Crops/Livestock Systems Research

FS - A Existing systems, but without livestock
Approach: Monitor

FS - B Existing systems, and with livestock
Approach : Monitor

FS - C Existing system Gradually Improved
Approach:
a. Improve management (subsidized credit available for livestock)
b. Gradually increase perennial crops
c. Keep within farmers capital and labor constraints

DS - D Improved systems with Intensification
Approach:
a. Improve management
b. Increase perennial crops
c. Assume government intervention for capital and labor constraints

Footnotes and Acknowledgments

[1] Crop-Livestock Systems Research Project Coordinator and Assoc. Professor, Institute of Animal Science, UPLB, Laguna, Philippines; Senior Research Fellow, Rice Fanning Systems Program, IRRI Los Banos, Philippines; and Head, Rice Farming Systems Program, IRRI Los Banos, Philippines, and Coordinator, Asian Rice Farming Systems Network, respectively.

[2] With special acknowledgment to the ARFSN collaborators in FSR and crop-livestock research.

[3] Pa-iwi - Traditional livestock rearing-sharing scheme thereby lender provides animal to caretaker. Incremental profit is split 50:50 upon sale, and initial animal value to lender.

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RICE, MEAT AND MILK: SYSTEM COMPONENTS IN NORTH EAST INDIA

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1.Introduction

In the recent history of agricultural research equity and efficiency have often been cited as implicit objectives of technology-for-development programmes (Ashby 1981, Boserup 1970). The recognition of economic polarization between households as a result of technological intervention (Farmer 1977) established the need for inter household analysis as a component in agricultural research. More recent research findings have suggested that intra household analysis is equally as important for formulating programmes to meet the above objectives (Acharya 1984, Feldstein 1985).

The degree to which sexual differentiation cuts across social and economic groupings and the way in which these are dynamically related varies according to, often very specific, location (Richards 1985, Sutherland 1986). Because of this it is important to avoid resting on assumptions drawn from experiences elsewhere. Therefore to assist in ascertaining research priorities systematic analysis of both inter and intra household analysis is called for as an integral part of any farming systems research programme (Hill 1986, Rhoades 1985).

This paper focuses on two components of a particular farming system in North Bihar in India. The data are drawn from a research programme where agricultural scientists were examining the possibilities of new rice technologies. Clients were identified as resource poor producers operating under rainfed conditions (see appendix 1) . Inter and Intra householdinformation collected is used to show that knowledge of time allocations, decision making and labor use can directly assist efficiency within the confines of this particular research domain. It is also used to demonstrate how, by looking at other elements of the system (eg. livestock and feed), the productivity of more than one system component can be enhanced. Consideration of the relationships between these components illustrates how the underlying principles of an efficient programme with equitable and efficient results can be integral to an agricultural research effort.

Within this framework the following analysis first outlines the social and economic organization of the village in relation to agricultural/livestock production and resources. Secondly it focuses on the intra household differentiation across these groupings. Finally there is a discussion of the agricultural research interests that emerge from this kind of social and economic information.

2.1.The Village.

Belkunda village lies an hours drive to the north of the Ganges and the city of Patna in Bihar, India. Farming is dominated by the chaur conditions found in this area (see appendix 2). Chaurs

consist of dished depressions in the soil surface up to 5km across and reaching depths of 3 meters in the centre. During the rainy season (June -October) they are subject to flooding and water logging. Water levels recede during the remainder of the year exposing Slopes of 5-15 degrees and soils varying from sandy loams at the top to heavy clay at the centre of the depressions. Soils tend to be neutral (Ph 6.8-7.0) with goad potash and nitrogen content but low in phosphate and generally zinc deficient. For social and economic survey purposes land was divided into five types: i. fully irrigated upland, ii. partially irrigated upland, iii shallow rainfed, iv. deep rainfed/chaur, and v. banjar or waste land.

Temperatures are highest in April and May, reaching up to 38 degrees centigrade. Rains in 1985 were heavy and late with an average of 372mm per month falling between July and October. As distribution and density of precipitation affects cropping patterns and labor use specific observations within this paper relate to the conditions of l985/6.

Paddy is the main subsistence crop with different varieties being grown at different points of the chaur. Local varieties dominate, especially in deep water where no modern cultivars have as yet been found suitable. No irrigated rice is grown, although some bonding is done for nurseries, and no rice is sold. Deep water yields in 1985, which was recognized by farmers to be a bad year, averaged 1425 kg/ha according to growers. (Government figures quote an average of 792kg/ha between 1973 & 1983.) Other staples include millet, wheat, channa, and mung. Maize growing has decreased in latter years due to a reported increase in insect attack. A variety of vegetables, including potato, and fruits are cultivated - generally in small plots close to the home. Castor and mustard are grown for oil. At present tomato and tobacco are the main cash crops. Animal feed (Janera)is only grown now as a field border or very occasionally as part of a mixed crop.

Only one farmer in the village owns a tractor, which is available for hire to other cultivators. Three families have diesel pumpsets - which are again hired out. Oxen are the main source of draught power being used either by families alone, hired cut with a driver for cash or used in reciprocal exchange relationships. Water is readily available in this village with the dry season water table lying at about 5 meters. Cultivators unable to use mechanical pumps use a combination of scooping and channels for irrigation.

2.2. The Village Disaggregated.

There are eighty seven households in the village divided into nine caste groups (4 scheduled, 3 backward) and a Muslim community. All data referred to in this paper relate to that drawn from a sample of thirty eight households. Sample selection was based on agricultural labor use or connection with agriculture/livestock. Households not falling into these

Categories are ignored for the purposes of this analysis. A total of two hundred and fifty four people were included with a male; female ratio of 1:0:8.

Five income strata were devised based on households' gross annual income. As Table 1 shows there is a positive correlation between income group (1 is high) and size of holding, with the richest 9% of cultivating households holding 74% of the land and the poorest 31% holding 4% of available land. Furthermore, in the lowest income strata, 69% of land cultivated is on a sharecrop basis, and of the 69% is chaur (only good for deepwater, risky paddy). Sharecropping terms mean that 50% of gross product accrues to the landlord. In the low income group 16.6% of owned land is partially irrigated, no farmer owns fully irrigated upland, and only 9.5% of total sharecropped land is of this type. Conversely in income group 1 23% of land owned and cultivated is fully irrigated, no farmer owns fully irrigated (use mainly for growing tomato and tobacco as cash crops), 11% is partially irrigated (wheat, maize and vegetables) and 21% is chaur. Of land rented out by the highest income group 53% is chaur, 29% is fully irrigated upland and 18% is shallow water rainfed (used mainly for paddy and tomato in Kharif season and wheat, gram and mung in rabi). Land ownership and access is therefore skewed both in terms of gross amount available and in terms of the land quality as measured by returns and security of that return.

Original stratification of the sample was carried out along the lines of net use of agricultural labor. Four strata were formed- i. households who were net hirers in of agricultural labor, ii. households who were net users of family agricultural labor, iii. households who were net hirers out of agricultural labor, and iv. Households who used no agricultural labor for cultivation but who owned land or livestock. This stratification proved to be a relatively good indicator for the resource wealth of households. Disaggregated in this way households displayed similar patterns in ownership and access to livestock as to land. Table 2 shows the positive correlation between high income group and high incidence ownership of livestock. In labor use strata 3, (net hirers out of family agricultural labor), it is noticeable that although 90% of households have access to basis. This means that these households will only receive half the gross income derived. As household income falls the incidence of shared
animals rises.

Table 3a illustrates the importance of various sources of income to the households in the difference strata. Table 3b details this more closely. For example, 62% and 72% of households in low income groups (4 & 59% in income group 5. Alternatively 72% of the income for group 1 was derived from agricultural/ livestock production, and 19% from non-agricultural wage sources. Although wage labor is

an important source of income for a large number of households the level of mages is such that subsistence levels of consumption are the norm, Agricultural mages will be paid in both cash and kind and are often tied to other factors such as renting of land, availability of loans or security of future work. Imputation of market values therefore becomes inappropriate.

There is generally little surplus to invest in any form of asset. Ownership of capital goods is directly related to households annual income as is the educational level of members indicating that at present there is little chance of poorer families investing in the only readily available resource ie. human capital. It is only richer families producing cash crops that have full control of the generated income. In all other cases cash crops were produced on sharecropped land. Hence although there exists a situation of strong market awareness in this village the mode of production is not purely capitalist.

Although labor is the one commodity that poorer families can sell its market value, as discussed above, is often affected by many factors. Labor was initially identified by cultivators as problematic during peak agricultural times. Investigations were, therefore, carried cut on time allocation (using a Random Instant methodology), and hired labor use (monthly recall). Because of the methodology used Time Allocation data is mainly discussed in the section below on intra-household analysis. However, in relation to what occurs between households, it does give a clear picture of when family members are involved in activities external to the domestic unit. Among these number education, agricultural wage labor, exchange labor, social events or other waged activities.

Of particular importance to this research was the amount of time men and women of different economic groups mere spending in agricultural mage labor, and at what times of the year. As expected July/August and November/December mere periods of maximum intensity for both sexes. The former represents the beginning of the agricultural season when land is prepared and crop growth initiated. The latter is the time of harvesting, processing and storage. Neither male nor female members of income group 1 mere involved in agricultural mage labor. There mere only two occurrences of income group 2 males working for agricultural mages mere observed - and none for females of this group. In lower income groups the pattern was one of increasing use of time for males in agricultural mage labor as the household income fell. Female patterns showed an increase in other forms of wage labor that peaked slightly after the men’s. This indicated a hiring of their services for processing and storage work. There was not a smooth increase in the amount of time women spent as mage workers by income strata. This can be explained by the attachment to households as semi-permanent domestic workers by some income group 3 women. The subsequent remuneration improved household income but skewed the pattern of female mage employment.

Farmers who hired in labor in only one month stated that they had hired -females as agricultural wage laborers. When including post-harvest work as a task -for which people were hired instances were recorded of hiring female laborers. Table 4 shows the pattern of labor hired over the busy six month growing, harvesting and processing period. The discrepancy between the differences recorded for days hired in over time and days hired out can be explained by the movement in of labor from other locations during times of high demand. For these migrant workers the influences upon the price that they will accept for their services are different than for those people resident in the village. Their mobility has meant that they command higher rates than the laborers tied to one location. Hirers of labor report that increasingly work is done by groups of these laborers on a contract basis. They also commented that work was done faster and with less supervision. The laborers stated they felt they were able to earn more money and liked the control that they had over both their own time and the payment they received. There were also cases where males from the village were moving cut to work elsewhere at these peak times - suggesting that mobility has to some extent broken the previous bonds and is changing the nature of labor relations.

2.3.The Household Disaggregated

Each household in the sample was disaggregated by sex and age, and details on decision making, time allocation and labor use collected accordingly.

(i) Labor and Time.

The Time Allocation data not only give an indication of the amount of time is spent on various activities at different times of the year, but also of who does what. An underlying assumption of this analysis is that there are four ways in which the sexual division of labor manifests itself. These are that tasks are sex sequential, sex segregated , sex supportive or sex substitutable. with this framework it becomes easier to see the dependency network within household labor relations and to ascertain what constraints or opportunities exist for changing or introducing new practices.

Table 5 outlines seventeen major time use categories and the percentage of time spent in these activities by men and women between the hours of 0500 and 2200 over seven months. This information is then broken down by income strata where markedly different patterns of activity occur. A more detailed breakdown of these major categories into a total of 161 activities has served to both identify specific activities and highlight particular relationships within a major area.

For example we find that, in the aggregate information shown in Table 5, women spend on average 5.7% of their time in the major

category of Livestock and Poultry. The detailed breakdown shows that within this category of time use 4.1% of their time is spent collecting fodder. However disaggregation by income group shows that, over the total time period, strata 1 women spent no time in fodder collection, while women in strata 2 spent 1.2%. Strata 3 women spent 4.4% of their time collecting fodder, 4.1% in strata 4, and 11.3% of their time in this activity in strata 5. With men the pattern is slightly different : 1.1% in strata 1, 4.1% in strata 2, 1.7% in strata 3, l.9% in strata 4, and 5.0% in strata

It appears then that, for the richest households, animal care is a sexually segregated task. In strata 2, in which women do not collect fodder all the year round, the time women spend is above their overall average during July and August. This is when fodder is in scarce supply and males are spending a lot of time in crop growth and maintenance. This clearly indicates that activities are sex substitutable or sex integrated. July is a the time of high agricultural mage employment, As only 0.5% of the sample involved women who worked as wage laborers it is reasonable to suggest that the data relating to fodder collection in income strata 5 further supports the idea that this activity is sex substitutable. As males assume a heavy agricultural mage work load the females in this strata spend an above average time in fodder collection (7.0% against an average of 4.3%, and 13.1% against an average of 11.3%).

The overall pattern is primarily one of females increasingly being involved in fodder collection as household income falls. Pursuing this further it seems that a similar pattern in the substitution of labor occurs between the sexes, ie. rising as income falls. This is indicative of a conflict between the social ideal of women being kept in purdah and of economic pressure causing deviation from this ideal at times of stress when women will take part in some activities outside of the domestic sphere.

In relation to the production of paddy there is a shift in emphasis - although the general structure of the argument is the same as above. Activities associated with rice production were divided into three categories, i. Field located work (crop growth & maintenance, harvesting, drying, carrying),ii. Household located work (drying grain, threshing, storing), and iii. Processing work (cleaning, parboiling, post boiling drying, other). The following results were obtained relating to percentage of time spent during seven months.

Category i		Category ii		Category iii	
Male	Female	M	F	M	F
9.5	1.3	0.6	1.6	0.2	5.5

Female participation decreases as work location moves away from the home particularly in high income groups. Group 1 females do no field work while group 5 spend 0.6% of their overall time in

the fields. Male field activities increase as income decreases from income group 1 spending 0.4% of their time in them, group 2 1.0%, group 3 1.8%, group 4 l.9% and group 5 4.4%.This table also demonstrates the sex sequential nature of rice production. In this labor relationship the efficient execution of one task is dependent on the efficient execution of the preceding task. It is a chain of dependency that has actors of different sexes sequentially performing different roles.

The disparity observed in time spent by men and women in the execution of the three groups of tasks also leads to the conclusion that if looked at more closely it is likely that there will be some activities performed by one sex only. These are tasks that are sex segregated. In the fields we find no recorded evidence of women engaging in ploughing or irrigation. In processing the same applies for men in husking, par boiling and post boiling drying. The reverse occurs with oil pressing where only men have been observed participating. In other areas this clear delineation is cut across by income group, and a pattern of labor substitution occurs in the poorer groups where females will sow, weed and transplant rice.

In the first part of this analysis labor was used to illustrate the links between fodder collection and rice production. Fodder is collected throughout the year. Peaks and troughs of time taken in this activity occur as shortage of supply and problematic access in July means high time inputs are called for. Shortage in labor during the period of rice harvesting, processing and storage means less time is available for the collection of animal feed. Using the same connection, ie. available labor time, there is evidence that although some duties may not immediately appear as important to the production of rice there is a direct link in terms of work burden. Instances of sex supportive roles are those of cooking, child care, religious/social obligations and other female domestic functions. As an example, in November when rice harvesting begins, through to January women spend more of their time cooking and serving the family than during the rest of the year. This is related to a decrease in the actual amount of time females were observed eating and engaged in personal grooming and hygiene. Leisure time in November was also the lowest recorded. There was also a marked decrease in the amount of religious activity as time spent in domestic duties increased. As demand for supportive services increases in one area it seems that time allocations are manipulated to satisfy this need. This occurs apparently in some cases to the detriment of the person supplying the service.

The situation in the rice production of this village is thus one of an overall concept of sex sequential activities, backed by a social ideal of sex segregation, with evidence to support the proposal that sex supportive roles are important to the system. Cutting across this chain of interdependency are economic forces that influence to differing degrees the amount of task integration and substitution occurring between the sexes.

(ii) Decision Making.

What people physically do is not the only factor that affects the way in which a system functions. Taking a further step into descriptive analysis and considering efficiency within an agricultural research programme it seems important to find out who makes decisions about what is done (and by whom). Three areas of participation in decision making were considered, i. who initiated, ii. who influenced and iii. who executed decisions.

Investigations were carried out in eight areas of household decision making. The results for three of these areas felt to be of immediate importance to the agricultural system are summarized in Table ó. The table is concerned with female participation but this is merely an attempt to redress the balance in a situation where moments influence was previously considered to be minimal. In most cases female participation increases as the household becomes more involved in agricultural wage labor (proxy for resource wealth of household) indicating that the inter household status of women is highest in low income families ie. they have greater control over their lives and greater authority within the family unit.

Within the context of decision making relating to agricultural technology women hardly ever carried out the decisions. However they increasingly initiated and mere involved in discussions about agricultural technology as the households became poorer. Investigations into the Disposal of Family Resources examined decision making in expenditure on major items such as agricultural equipment and animals, again a general inverse trend between female participation in discussion and the resource wealth of the household can be seen. Figures for strata 1 women can be related to the fact that females of rich households often have cash or gifts from parents over which they have some control. Cash and Kind Expenditure looked at more regular outgoings. Influence in this area mould affect expenditure on items such as smaller agricultural inputs including seed (type, variety and amount), fertilizer etc. Investigations mere not carried out into the relative importance of these latter expenditures to different households. However it is felt that where cash is tightest there mould be the greatest competition for use of this resource and that male/female discussions could play an important role in the possible adoption rates of technologies.

These findings illustrate the fact that both men and women are involved in decision making with the ratio of women’s to men’s participation increasing as household income decreases. Higher percentages for females can be correlated to their direct participation in the activities that are the subject of the particular discussion. In the case of richer households this is only high in tasks carried out in the domestic sphere, As household income decreases women move further into participation

of those activities that have a direct relationship to incoming goods (cash or kind). It is therefore apparent that there is a relationship between moments intra household status and their participation in economic activities outside the domestic sphere. The ramifications of this for an agricultural research programme are clear. If the existing pattern of withdrawal of women to the domestic environment as household financial status grows continues, then increasing yields and overall household income is likely to result in a loss of intra household status for women.

3.1. Implications for Agricultural Research.

The preceding sections have shown that data on labor use, time allocations and decision making can describe the dynamics of relationships within a farming system, both within and between households. It remains nom to demonstrate why such information can be useful if there is concern-over horn the outcome of research relates to issues of equity and efficiency. An underlying assumption is that the second cannot exist without the first.

Equity concerns can be divided into two crude categories corresponding to inter and intra household. The former, as commented on at the very beginning of this paper, is related to the avoidance of economic polarization within a society. The concern of the latter focuses on the issue of status within the household. Efficiency is the concept that links the two. In terms of efficiency within the village it is inefficient, particularly in aggregate welfare terms, to displace smaller cultivators from land. It is also inefficient to utilize capital inputs where labor (which in this case has low alternative market options) is available and substitutable. Within the household the decrease in women’s status, as household incomes increase, means they have less control over the welfare of the whole household. Secondary sources have recorded similar cases where female status has declined as they have lost control over economic decisions even though gross income has increased. Therefore it is important to ensure that, if innovations are to increase income, strategies are adopted that at least do not decrease females power within the household unit. A further step in this argument is that if measures are taken to protect or enhance female status then there is the possibility of utilizing presently inaccessible female labor.

3.2.Livestock and Rice.

Different groups within the village have different needs and will be affected by new technologies in different ways. This applies to both economic and sexual variables. Social and economic information can help to identify intended clients and can also point to relationships that may be affected by intervention between groups.

In the agricultural research programme under discussion here the clients had already been identified as resource poor cultivators. The data shows that for many of the households at the lower end of the income scale agricultural wages play a major part in household earnings. Therefore, if technological change is likely to affect the hiring of labor, analysis of richer households –and particularly the dynamics of their resource allocation- is required for agricultural research focusing on the poor. For households involved in cultivating their own crops and in the agricultural wage market there are also ramifications for changing labor patterns. Higher demands would mean juggling time allocations, which in turn could affect the adoption of recommendations. Bearing this in mind it seems that research into new rice varieties and techniques mould be less likely to have inopportune effects. There mould also be a higher probability of adoption if attention mere paid to the staggering of timing of peak activities. Further, long grain varieties need to be concentrated on. This type of grain both commands a higher market price and was preferred for consumption by 87% of sample households.

Time is the major dimension where sexual variables play a part. It has been shown that both men and women are part of the production system. Different roles are occupied according to economic situations. A general observation is that females direct involvement in the agricultural/livestock system is in fodder collection, rice processing and storage. From the information gathered it appears that women are likely to be withdrawn from wider economic participation into the domestic sphere as household earnings grow. Coupled with a concern to maintain, and hopefully improve, women’s status it seems that attention should be paid to ways in which they can remain involved in, and build upon, activities that currently give them some economic control. Livestock appears to be a possibility. Even in income group 2 the pattern of sex task substitution was one of females collecting fodder when demand for male agricultural wage labor was high. The return to labor in terms of tending livestock is very low - partly because of the time spent gathering feedstuffs and partly because of the high rate of animal mortality. Little milk is available to many of the households rearing animals as yields are only sufficient to maintain a calf. Again it is only in richer households that milk was found to be readily available with both buffalo and milch cows being kept for that purpose. Concentrates mere used as supplementary feed in these cases. Milk has a high market price and could also help to improve the nutritional status of households if more mere available. Feed is a definite constraint on production at present. It is surprising then that so little is grown as a field crop, or that no tree or perennial species - apart from occasional banana biomass - are used as a source of fodder. By-products of pulse crops grown are currently used as feed, which would suggest that inter cropping with rice - or wheat in the winter - could be another useful direction for research investigations.

Meat is also a costly commodity with goats as the primary source. Goats, predominantly the concern of lower income women, are usually tethered with little other food supplement apart from household waste. Mortality rates are high, and most of these animals are kept on a share basis from richer households. Milk production for kids is problematic, reflecting the poor physical state of the nannies. Improving feed for these animals could be one way of augmenting and ensuring output and therefore earnings.

Chickens are not of direct interest in discussions of rice/fodder linkages, apart from the fact that they consume broken grain and chaff, With heavier harvests quantities of both of these should increase resulting in an increase in the number of fowl able to be supported. Only low caste or Muslim groups can keep poultry. As these tend to fall in the low income strata, an improvement in the quantity of eggs and meat, could be seen as a beneficial side effect.

However there does have to be time to deal with these extra animals and their products. It was noted earlier that juggling of time budgets occurred when activities associated with rice took precedence. Even if attempts to introduce new varieties/ techniques that spread labor demands were successful, larger harvests or more intensive techniques could mean that time became more intensely used during certain parts of the year. Remembering the substitution of female labor that took place when male labor was in demand in the fields it follows that a higher burden will be placed on women. For this reason, and also if emphasis is to be placed on livestock as the means to economic participation of females, it is necessary that fodder, as a key element, be readily available.

4. Conclusions.

The basis of the argument contained in this paper has been that components within the rice production system in the village surveyed are related in such a way that intervention causing a shift or change in one will automatically cause a change in another. Two major components of the rice production system, rice and livestock, have been examined using analysis of intra and inter household information to show that cause and effect relationships differ over sexual and economic groupings. Four types of labor relationships have been developed and used to explain and understand the patterns of time allocation and decision making.

Within this framework time allocation data has demonstrated the nature of labor relationships both within the household and within the local economy. Linked with the time allocation, hired labor use information has given a picture of demands made upon time and labor by particular activities and households during certain parts of the year. Decision making questionnaires revealed patterns of control over resource allocations.

The use of such information has been shown in the way it can trace the relationships between different elements within a production system. There-fore areas for intervention can be highlighted. Information such as has been discussed in this paper can suggest where manipulation of one specific aspect can be used in a positive way develop strategies to increase the productivity of another aspect.

In placing emphasis on disaggregating data over sexual and economic variables it has been shown that research activities can ensure efficiency at the investigative and implementation stages. Both direct beneficiaries and secondary interest groups can be identified. The respective needs and available resources of each can be ascertained. An awareness of the different implications for these groups therefore means that equity issues can also be considered as an integral to an agricultural research programme.

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APPENDIX 1

Outline of Technical Research.

l. On Farm Trials-Rainfed Paddy
    i. Varietal Improvement
    (a) Shallow water rain-fed
        Vars:26
        Design: RBD
        Plot Size: 12 sq.rn.
        Rep:3
    (b) Deep water rain-fed
        Vars:l9(2 local checks)
        Design: Non-replicated observation rows
        Plot Size:12 sq.m.
    ii. Agronomy
    (a) Cropping System
        -Mixed cropping trials
        Rice/millet
        Rice/jute
        Rice/channa
        Rice/mung
        Rice/millet/mung
        -Cropping sequence trial
        Paddy/wheat
        Paddy/barley
        Paddy/linseed
    (b) Fertilizer Management
        -Chemical effects on yields in shallow mater conditions of different treatments of urea and super phosphate granules.
        -Bio-fertilizers (on station), effect on yields of inoculation in <50cm. water of azolla and blue-green algae.
2. Physiology
    (a) Submergence and drought tolerance.
    (b) Seed dormancy, photoperiod sensitivity, rooting system, spikelet shedding.
    (c) Tillering, growth and productivity.
3. Pathology
    Observation and screening of trials.
4. Entomology
    Survey for insect attack and population.
5. Soil Science
    Sample collection for classification.

APPENDIX 2

Site Description

a. Location

Belkunda Village, Mahua Development Block, Vaishali District, N. Bihar, India.

b. Research Environment

i. 24 degrees N.,85 degrees E.

ii. Elevation 0-100 meters

iii. Temperature

	J	F	M	A	M	J	J	A
1959-78 Ave	22.6	28.6	31.1	37.0	38.0	36.3	32.8	32.6
1985	22.9	26.3	33.9	37.2	35.2	35.7	31.2	32.5

	S	O	N	D	
1959-78	31.8	30.9	28.2	23.9	(MAX)
1985	31.5	30.2	27.3	25.3	(MAX)

iv. Rainfall

	J	F	M	A	M	J	J	A
50 YR AVE	19.8	17.8	7.1	13.3	34.8	135.9	300.5	291.5
1985	10.2	0	0	0	25.7	73.7	594.4	311.0

	S	O	N	D
50 YR AVE	209.8	77.8	5.7	2.5
1985	304.6	278.2	1.6	4.2

v. Rainfed Lowland i. shallow rainfed (up to 25 cm)
ii. intermediate rainfed (25-50cm)
iii. semi-deep rainfed (50-100cm)
iv. deep rainfed (100+cm)

vi. Soil (chaur conditions)
Texture variable: alluvium, silt deposits, clay deposits.

sandy
loam
loam
clay
heavy clay

slope
5-15
degrees

Ph 6.8-7
Phosphate content low
Zinc deficient
Potash content good
Nitrogen medium to high

c. Land Tenure

Type of Tenure	% Sample Households
OC	23.6
OC/RO	21.1
OC/SC	21.1
S/C	29.0

OC Owner cropped land
RP Rented out land
SC Land taken in on sharecropping

d. Social Structure

9 castes within village - 4 scheduled,3 backward Muslim community. Caste boundaries strong, delineation of tasks according to caste. High caste domination in political and economic spheres. Upper caste women subject to purdah restrictions.

e. Marketing Outlets

i Patna city
ii Local chowk
iii Field gate

f. Credit

i Grameen Bank in village. Interest rates 10-15%
ii Money lenders. Interest rates 60%

g. Cropping System

i Subsistence crops: Paddy (deep water/summer/single stands; shallow water/summer/alone or mixed with millet, channa; and rain-fed upland/summer/alone on with moong, channa, sorghum, urad, castor,);moong; channa; mill et(rainfed upland/mainly green for fodder crop); urad; jute; wheat (irrigated upland/winter/alone or mixed with mustard);maize(rainfed upland, little grown now due to insect losses);vegetables/fruit(squash, tomato, aubergine, onion, garlic, okra, potato, cauliflower, mango, banana, lychee (not common), grapefruit (not common).
ii Cash crops: Tobacco, tomato.
iii Crops and system very dependent on variable precipitation. Paddy is both broadcast (deepwater & very wet conditions) and transplanted (sometimes twice).
iv Inputs

a. Labour: Peak times

(i) men: land preparation (onset of rains after upland needing (1-2) months after sowing rice, tobacco transplanting rice, harvesting rice.

(ii) women: rice, post harvest activities, female labour hired for harvesting rice in dry years. Other direct involvement in agricultural production is through time spent in fodder collection and livestock care throughout year.

(iii) Hirers of agricultural labour state that this is a major, and increasing, cost and that shortage of workers is a constraint on production.

b. Mechanization: l tractor in village available for hire. 92% cultivators use oxen as source of draught power. 3 irrigation pumps in village, after rain much irrigation done by hand (water table approx. 3 m).

c. Seeds and chemical inputs readily available on black market at costs averaging 10% more than government recommended prices. Official outlets subject to untimely shortages, bribes often necessary to ensure supply.

Table 1

Cultivators and holdings Over Income Strata

Income Strata	Average Size of Holding (Ha)	% Cultivated Land in Village	% Cultivators in Village
1	7.48	74	9
2	1.02	8	9
3	0.41	9	28
4	0.26	5	23
5	0.15	4	31
		100	100

Table 2

Ownership of/Access to Livestock by Different Resource Groups

Labour Use Strata	Total	Percentage of Strata with Livestock Owned	On Share
1	100	100	0
2	100	89	0
3	14	90	86
4	86	50	14

Income Strata	% Animals on Share
1	0
2	0
3	29
4	21
5	50

Table 3a

Ranked Sources of Household Income

	Percentage of Village		
	Primary	Secondary	Tertiary
Agricultural/ Livestock Production	17	38	0
Agricultural Wage Labour	31	5	1
Shop	12	0	0
Petty Trading	13	8	1
Tea Stall	2	0	0
Skilled trade	15	0	0
Service	2	0	0
Profession	5	0	0
Government Employment	3	5	0
Other	0	1	3
TOTAL	100	57	5

Table 3b

	Income Strata				
	1	2	3	4	5
% Income from agricultural production	72	44	12	23	25
% Income from wage	19	37	58	53	59
Total	91	81	70	76	84

Table 4

Average Number of days of Agricultural Labour Used Per Month by Sample Households in Labour use Strata 1

Activities		Days per Month (Male = M Female = F)						
		JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	M	10.2		14.4	2.1			
	F	0.5						
2	M	2.0	32.0					
	F							
3	M	12.3	32.3	9.6	0.5			0.3
	F							
4	M	31.2						
	F							
5	M	8.8	6.4	0.6		0.4		
	F							
6	M	1.0		0.4	0.5			0.4
	F							
7	M	0.1	1.0					
	F							
8	M		80.3	34.3				
	F							
9	M			2.4				8.3
	F							
10	M			0.3				
	F							
11	M			0.3				
	F							
12	M				6.5	0.1		1.0
	F							
13	M						18.0	69.3
	F							0.7
14	M							
	F							8.3
15	M						25.6	33.3
	F							
16	M							1.3
	F							
17	M					5.0	2.8	
	F							
Total		66.1	152.0	62.3	9.6	5.5	46.4	122.9

Activities

1 Weeding Rice
2 Sowing Rice
3 Ploughing
4 Tobacco Processing
5 Land Maintenance
6 Applying Fertilizer: Chemical/ Organic
7 Sowing Vegetable Rice
8 Transplanting Rice
9 Sowing/planting Tomatoes
10 Appling Weedicide
11 Irrigating
12 Preparing Seed Beds
13 Harvesting Rice
14 Beating Rice
15 Weeding Tobacco
16 Sowing Wheat
17 Transplanting Tobacco

Table 5

Time Use By Men and Women Over Seven Months

		% Time Spent	
		Men	Women
Major Activity Category	1	8.8	5.7
	2	0.7	0.0
	3	0.1	0.0
	4	1.9	0.2
	5	1.0	0.7
	6	1.4	0.0
	7	0.2	0.2
	8	1.4	1.4
	9	0.2	1.5
	10	15.0	2.3
	11	1.6	0.1
	12	2.1	20.3
	13	1.6	7.8
	14	6.6	2.0
	15	4.0	6.6
	16	46.3	47.0
	17	7.1	4.3
	Total	100	100

Activity No	Activity Category
1	Livestock and Poultry
2	Land Maintenance and Preparation
3	Fertilizer/Manure
4	Crop Growth and Maintenance
5	Harvesting and Storage
6	Vegetable/Fruit
7	Hunting and Gathering
8	Manufacturing
9	Food Processing
10	Participation in Local Economy
11	Construction (Household)
12	Domestic Activities
13	Child Care
14	Education
15	Social/Religious
16	Leisure
17	Other

Table 6

Women’s Participation In Decision Making

	stage area	% Involvement by Women								
		Initiation			Consultation			Execution		
		a	b	c	a	b	c	a	b	c
Labour Use Strata	1	9	70	3	18	74	6	9	5	0
	2	0	76	6	20	78	9	0	32	3
	3	25	84	6	50	89	23	50	58	0
	4	50	90	3	50	92	6	0	70	3

Area a Disposal of Family resources
b Cash Kind Expenditure
b Agriculture Technology

Outreach Pilot Project: A Case Study of a Small Ruminant Farming Systems Research and Extension Project in West Java

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This paper describes the development of Outreach Pilot Project (OPP), a farming systems research and extension project in Indonesia whose special focus is livestock. The project began in 1984, initiated by the Small Ruminant Collaborative Research Support Program (SR-CRSP) and the Indonesian Research Institute for Animal Production, known as BPT, in Bogor, West Java. Now, one and a half years later, we are beginning to form some judgments about the development of the project and its likely future direction. This paper will summarize these judgments.

The outline of this paper will be as follows. First, we will describe briefly Indonesian agriculture, with special emphasis on small ruminants. Second, we will describe the institutional collaboration which underwrites the project. Third, OPP will be described as a model for agricultural research and extension. Fourth, we will discuss our most current research findings. Finally, we will try to look into the future to see what directions OPP might pursue to improve itself.

Indonesia is an island nation (over 13,000 in all) that includes some of the largest islands in the world -- Borneo, Sumatra, and New Guinea. Its population is over 170,000,000, making it the fifth most populous country in the world behind China, India, the Soviet Union, and the United States. It is estimated that by the year 2000 — only fourteen years away — Indonesia will have a population of nearly 223,000,000. While Indonesia has faced a series of daunting challenges over its forty year history as an independent nation, it will surely face its most serious challenge in the next two decades as it strives to find the means to educate, feed, house, and employ this growing human population.

Situated in the humid tropics and with highly fertile volcanic soils, it is not the least bit surprising that food crops and estate crops form the backbone of the Indonesian rural economy. Today 56% of the population works directly in agriculture.[1] Agricultural products provide roughly one-third of Indonesia's gross domestic product. Considering all agricultural products (including food crops, estate crops, livestock, forestry, and fishery), food crops contribute 58% of that one-third of gross domestic product.[2] By far the most important food crop is rice. Land devoted to rice production alone is greater than that devoted to all other staple crops combined.[3]

On Java, where our research is located, nearly 100 million people live on a land area approximately the size of California. With one of the world's highest population densities, it is not surprising that food crop-based farming systems predominate. Java is characterized by three major cultivation zones, defined primarily by elevation, and each is associated with a particular cropping profile: in the lowlands, wet rice farming is dominant; in the upper elevation slope lands, the revenue producing estate crops such as coffee, tea, cocoa, rubber, and spices, are grown; the highlands are characterized by intensive vegetable production systems.[4]

Land holdings in Indonesia are generally quite small, just 1.69 hectares per agricultural household.[5] On the island of Java the figures are even smaller; in recent years farm sizes there have been declining precipitously, and the current average size has fallen to 0.3 hectares per farm.[6]

Farming systems vary greatly throughout Indonesia, from intensive rice farming on Java, to slash-and-burn horticulture in Central Kalimantan (Borneo), to mixed crop/livestock agriculture in West Sumatra. There is considerable interdependence between the crop and livestock sectors within Indonesian agriculture. Most farm households depend on both crops and livestock. In a food crop-based farming system, animals provide draft power to till the fields and manure for fertilizer. Crop by-products serve as an important source of feed for livestock. On such farms, livestock enhance the overall efficiency of the farming system.

However, because large ruminants are not economical on small acreages, there has been a large increase lately in the sale of cattle and water buffalo formerly used for draft power. This is especially so in West Java where declining farm sizes have combined with increased demand for meat from large urban markets to bring about declining numbers of large ruminants. This situation, however, is not so pronounced in other provinces of Indonesia.

On small farms there is little land for grazing or fodder production and intensive "cut and carry" confinement or semi-confinement husbandry systems for small ruminants have become well developed. Fueling this trend are increased crop intensities and yields of rice which have increased the supply of crop by-products and residue yields available for feed. Tree crops also provide a wide variety of livestock feeds, as do grasses and leaves gleaned from hedgerows.[7] For small farmers, sheep and goats can be a substantial source of income, especially for those who own no land. While they earn just over one-tenth of the agricultural income for farmers who own land, they account for one-fifth of farm income for landless producers.[8]

In spite of the predominance of food crops in general, and rice in particular, livestock contribute approximately 10% of the value of agricultural production on Java.[9] The three million sheep and seven and a half million goats fill a vital economic niche for the smallholder there. One out of every five farmers in Indonesia raises small ruminants. The Indonesian livestock sector satisfies most of the national demand for meat and eggs. Manure is an important livestock by-product, providing fertilizer for high value cash crops like fruits and vegetables. And for the smallholder, livestock act as a form of savings and capital. Additionally, sheep and goat meat is especially important at religious feasts and holidays when other meats may not be eaten. In the month in which Idul Adha falls, for instance, the sale of sheep and goats may double.[10]

The typical livestock kept on Javanese farms include sheep and goats, chickens, ducks, and occasionally, water buffalo or cattle. The sheep breeds found on Java display a continuum extending between two main types, the Javanese Thin-tailed hair sheep, prevalent in West Java, and Fat-tailed wool sheep found mostly in East Java. Both types are known to be highly fertile, but of low mature live weight. Lamb mortality tends to be high, partly on

account of low birth weights and partly because of unpredictable multiple births. The Kacang (peanut) goat is the indigenous type and Kacang Etawah crosses are also common. The Etawah is actually a cross between the Jamanapuri imported from India and better local Javanese goat varieties. Though essentially a milking goat, the Etawah is rarely used for milk in Indonesia. Both the Etawah and the Kacang are valued almost exclusively for their meat.[11] In West Java sheep and goats are marketed through a village trader, usually to pay for wedding ceremonies, religious celebrations, or school fees.

Most sheep and goats are managed today in much the same way they were some fifty years ago. Yet technologies now exist that can greatly increase small ruminant production without disrupting farmers' lives. Many have been developed and proven in other countries. SR-CRSP and BPT are trying to adapt these new technologies to fit into Indonesian farming systems to solve local production problems and raise farmers' incomes.

Small ruminant research in Indonesia is conducted through the Agency for Agricultural Research and Development, an arm of the Indonesian Ministry of Agriculture. The Central Research Institute for Animal Science, CRIAS, is an umbrella organization that oversees the work of two institutes, the Research Institute for Animal Production, known as BPT, and the Research Institute for Veterinary Science, known as BPV. Working with other researchers, educators, and livestock extension specialists, the scientists in these two institutes do research to improve small ruminant production in Indonesia.[12]

The United States has been collaborating in a comprehensive small ruminant research program in Indonesia since 1980. The Small Ruminant Collaborative Research Support Program, funded through the U.S. Agency for International Development, is a cooperative effort with the Research Institute for Animal Production (BPT). For nearly six years BPT and SR-CRSP have been working together to solve some of the most pressing small ruminant production problems in Indonesia. Because SR-CRSP is a multi-disciplinary project, the problems have been approached from a number of directions. The nutrition program has focused on feeding trials on BPT"s experiment stations using feeds that are available in the local villages. The breeding program has been working on establishing performance parameters of local breeds of sheep and goats and on improving breeding management practices. The rural sociology and agricultural economics programs have focused on characterizing the parameters of the farming systems used on Java and on identifying possible socio-economic constraints to improving production. In order to achieve SR-CRSP's long-range goal of increasing the supply of animal protein to Indonesian consumers and of increasing the incomes of smallholder sheep and goat farmers, it became necessary to take what had been learned so far in experiment: stations and apply it to specific village conditions.

We think there are good possibilities for improving the production of sheep and goats in Indonesia. Current production levels at the village level are about one offspring per year per adult female, with a lamb growth rate of 20-40 grams per day. However, based on research station experiments, there exists the potential to raise productivity to two offspring per breeding female per year.[13] This improvement we have learned could come about from a number of management improvements. First, there is an adequate genetic resource base of adapted livestock among sheep and goats which would allow the gradual improvement of production levels. Second, improvement of the

quality of feeds and nutritional supplements would aid in weight gain and general vigor of animals, particularly the females. Third, Indonesian sheep and goats breed year-round but there is normally no planned mating program conducted by smallholders. A breeding season based on feed availability or market demand would improve productivity greatly. Fourth, ill-health is a constant problem for sheep and goats in the villages. Internal parasites and mange are the greatest health problems which smallholders face. Periodic drenching could virtually eliminate the internal parasite problem. In summary, then, feed constraints are probably less a factor in the humid environment of Java, suggesting that with modifications to breeds, health care system and management, production could be significantly improved by adaptation of existing technology.

Using a farming systems approach, Outreach Pilot Project was begun in the fall of 1984 as the logical next step in the process of moving research and scientists out of BPT's research stations and into farmers' fields and animal houses. The project has a number of objectives, the most important for the long term is to improve the quality of farmers' management of sheep and goats. But the project is also designed to strengthen the dialogue between farmers and researchers; to increase farmers' awareness of the impact of management on production; to test and demonstrate new technologies; to breed genetically superior animals; and to promote collaboration among researchers at BPT and BPV, livestock extension specialists, and expatriate scientists employed by SR-CRSP.[14]

From the beginning, OPP was designed to encourage BPT scientists to work with farmers, to see them as partners in the research process, and to recognize the vast storehouse of knowledge they have acquired from working their farms. As is true in most less developed countries, Indonesian scientists, even agricultural scientists, generally come from urban backgrounds. As members of the middle class they anticipate a professional life of research publications, computers, comfortable offices and clean hands. However, as agricultural scientists, these expectations run counter to the kind of intimate, first-hand experience with farms and farmers that is essential if relevant, applied research is to be done. One of our greatest challenges has been to encourage the scientists to leave their offices and engage in field work. However, changing human behavior is never a quick or easy accomplishment.

The second goal of strengthening the dialogue between farmers and researchers is to stimulate BPT scientists to think creatively about farmers' production problems — to encourage them to listen to farmers as they describe their own particular situations, and then incorporate the farmers' perspectives into their research agendas. In the long run, agricultural research aims to improve farmers' lives by increasing farm efficiency, by raising farm income, and thereby enhancing farmers' sense of well-being. To the extent that farmers become a meaningful reference group to BPT scientists, research should become increasingly problem-centered and practical.

The third goal of enhancing the dialogue between farmers and researchers is to speed up the pace of research by placing newly developed technology into farmers' hands as quickly as possible in order to test its validity and to determine its acceptance among farmers. Farmers' experiences can then be fed back into the research process.

In order to accomplish the goals of OPP, the following mechanisms were developed. Together with livestock extension specialists from the Bogor district of West Java, BPT scientists selected fifteen local villages to participate in the project. Care was taken to insure that the various agroeconomic zones within the Bogor district were represented in the sample villages. In each village a small number of farmers, generally numbering between three and five, were brought together to form "farmers" groups," in effect small corporations which were given the collective responsibility to manage a small flock of sheep or goats. The farmers chosen represented a fairly wide range of social class, though the relatively richer farmers were over-represented. Some were landless, while others owned as much as five or six hectares of irrigated rice land. Some of the farmers were experienced livestock producers, and some were relatively inexperienced. The majority considered agriculture their principal occupation.

Each of the farmers" groups was organized around a "field laboratory" — a barn built with project money (Rp 125,000) on the land of one group member. The farmers were given sheep or goats -- five females and one male — and thereafter OPP staff would collect data on a monthly basis and would maintain supervision of the farmers" groups. Each field laboratory is designed to serve three functions: 1) testing ground for the introduced technology, 2) demonstration farm to spread knowledge of new technology to neighboring farmers, and 3) multiplication centers for the breeding of genetically superior animals. Although these farmers' groups are artificial social institutions in the sense that they have been created solely for the purposes of OPP, they closely parallel village conditions in a number of important respects, for example, small flocks, shared males, traditional animal house architecture and construction materials, and livestock as a secondary activity to food crop production.

A contract was drawn up between BPT and the farmers' groups which stipulated that over the next five years each group would return ten females and one male offspring. For each ewe or doe received by the group, the second offspring would go back to the Bogor district livestock extension service (Dinas Peternakan); the fourth offspring would be returned to BPT. Dinas Peternakan and BPT would then redistribute these returned animals to other farmers in the Bogor district. The contract will expire after five years, at which time the barn and remaining animals would be fully owned by the farmers' group.

Project staff visit each group once a month to administer treatments and to record information on weight, size, and health of the animals. A BPT scientist from each of the four disciplines supported by SR-CRSP (breeding, nutrition, rural sociology, and agricultural economics) participates in the monthly monitoring. Each participating BPT scientist has an expatriate counterpart from SR-CRSP.

The project initially focused on two management techniques not generally used by most small ruminant producers -- drenching animals for parasite control and feeding mineral supplements for increased nutrition. As new elements are added to the technology package provided to the farmers, their perceptions of the new elements are evaluated.

On the basis of nearly one and a half years of monthly monitoring and two surveys of animal performance and farmers' perceptions of the project, some preliminary judgments may now be drawn on the success of the OPP.

In general, participants in this project have found it to be useful. This finding, in itself, should not be surprising given the fact that OPP deviates from the conventional small ruminant research and extension project in which animals are merely distributed to farmers without any management recommendations at all.[15] However, in spite of the ambition of OPP, 11% of the respondents in a survey conducted in September, 1985 (Amir, Knipscheer, Mawi, and Spinhoven, 1985) said they felt it was too early to formulate an opinion on the ultimate value of the project. These farmers, at least, said that they would like to wait and see what OPP produces over time that is of value to them.

Clearly, however, OPP farmers think that there is a marked difference in the health and vigor of the test animals compared to their own animals. In the words of this survey, "(t)he ram provided by the OPP staff is in the eyes of the farmers perhaps the most important component of the technology (package)."[16]

This survey also found that the OPP farmers are very concerned with the labor input component of their production system.[17] This factor no doubt accounts for the favorable response farmers expressed toward mineral supplements, which in experiments conducted at BPT have demonstrated a significant positive effect on animal growth rate and on the reduction of lamb and kid mortality. Other recent research (Subandriyo, 1985) has confirmed that the first three months are the most critical in determining future health and performance in goats and sheep. Reduced lamb and kid mortality, and healthier and faster growing lambs mean increased production for the smallholder producer without a corresponding increase in labor.

Genetically superior rams, mineral supplements, and drenching for internal parasites were all viewed favorably by the respondents of this survey. But there is a vast difference between being favorably impressed by a freely provided input and being willing to pay for that input at full market price. And in this difference, OPP now faces a major hurdle. The survey respondents reported that under present market conditions they would find it difficult to continue the recommended practices unless some form of economic incentive was provided.

At present, the two treatments of drenching and mineral supplementation are paid for entirely by the project. The farmers are primarily involved in the management and care of the test animals, while the OPP staff are responsible for the purchase and administration of the drenching medicine. This is an artificial environment.[18] As a first step, however, OPP may not have erred in providing free drenching medicine to traditional farmers who are by and large skeptical of new and untried (at least to them) ways. The challenge now is to encourage the farmers to continue using a technology whose value they recognize but which to this point has been freely given to them. OPP staff now recognize that a new arrangement must be devised by which the farmer will share. the cost of the treatment with the project. Whether the arrangement eventually turns out to be based on a voucher, or some other system, the crucial point is that the farmer eventually bear a larger share of the treatments true market cost. As the technology gains

increasing acceptance among farmers, the share of the price paid by the farmer must be raised to a figure closer to the market cost of the input.

This problem is not so serious when it comes to mineral supplements. At an ongoing price of Rp 250 for mineral supplementation per month per farmers" group, it is clear that most farmers find this technology to be a less risky investment.[19]

Perhaps the most important lesson that the OPP staff has learned to date is that a technical solution to a problem is not necessarily a practical solution. Often, treatments are tested which are not commonly available in the market, or utilize expensive raw materials, or involve high fixed costs. It is essential that technology be screened through field experimentation for its technical soundness and social and economic acceptability. Specifically, this suggests that within OPP it is doubtful that farmers will adopt all of the technology under current market conditions which are now being promoted by the OPP staff. This in no way reflects on the inherent usefulness of the technology, but rather suggests that further research is needed on approaches to develop more effective grass roots strategies which can aid in the dissemination of the technology at sufficiently low cost to overcome farmers" resistance. In the future, research should focus on reducing the cost of the technology package.[20]

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HOMESTEAD AND HOMESTEAD CROP LINKAGES WITH LIVESTOCK AT THE JAMALPUR (BANGLADESH) FARMING SYSTEMS RESEARCH SITE*

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Introduction

In Bangladesh, Farming Systems Research (FSR) is being conducted in 23 sites by various agricultural institutes. At Jamalpur, activities commenced in 1983 under the Bangladesh Agricultural Research Institute. At all sites, much work has been done on Cropping Systems Research. Since 1985, all sites have adopted the holistic FSR approach. Also, all FSR scientists are committed to focus their research and development activities on the small farmer with limited resource endowments so as to strengthen and make the best use of their resources. In this process, it is important to improve their incomes and quality of life and to ensure their security without pushing them onto more marginal lands. The next logical step in this integrated approach will be Livestock, and Homestead Crop and Tree improvement.

While crop research has progressed rapidly and gained momentum in Bangladesh, livestock research lags behind and has had little impact on on-farm livestock performance (2). Most work on livestock have been restricted to cattle and poultry.

Sixty seven percent of the rural employed population of Bangladesh are engaged in Agriculture, Forestry and Fisheries. Ninety nine percent of the cultivable area is under food and fiber crops and the cropping intensity is 154 percent. Highland area is very limited and is mostly occupied by homesteads. Land is too scarce to set aside any for fodder crops or pastures. Roadsides, and edges of ponds and rivers are the only common grazing areas. Feed for livestock, other than from such common grazing areas come from field bunds, weeds in fields, fallow land, field and homestead crop residues, vegetation in ponds, perennial trees and household residues. Seventy seven percent of the total cultivable area is under rice and rice straw accounts for 90 percent of the feed available for cattle (3). The local breeds of cattle have been found to be more efficient in utilizing crop residues (5).

Livestock are housed within the homestead and are tended by all family members. The homestead and the land adjoining homesteads are the only land used for vegetable, fruit, yam, rhizome, spices, fuel and timber

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* Paper prepared for presentation at the Farming Systems Research Symposium, Kansas State University, USA, October 5-8, 1986.

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production. Thus, all livestock are an integral part of the homestead and are tightly linked with the composition of the household members and homestead crops and trees. Their interactions and complementarities, and the balance maintained, are much more profound and important than with field crops. It is considered that an understanding of the existing systems, linkages and inter dependencies, knowledge about which has not been formalized or published in literature, is a prerequisite to any work related to livestock, and homestead crops and trees.

The information presented in this paper is from what has been captured through direct interactions with members of farmer households during the last three years, surveys, case studies and field experience. By this process of collecting information, we have been able to crystallize our thoughts and formulate some strategies which hopefully would serve as guidelines in FSR.

LIVESTOCK

Livestock are housed just adjacent to or within households. Poultry, ducks and kids are often kept even within the living rooms of farmers, especially small farmers. They are all part of the family. Women play a more active role and devote more time than men in managing livestock. The income and expenses related to smaller animals are also often under their control and they play a dominant role in homestead production systems and decision making processes. Livestock is a substantially income generating enterprise. New technologies like the deep litter poultry rearing system have been rejected by all groups of farmers. Livestock health is inferior consequent to poor nutrition and grossly inadequate veterinary care. Use of agricultural machinery, except for irrigation, is virtually non-existent. Cows are also used for draft. An interesting feature is that livestock is also leased out and the produce shared by owner and lessee.

Small local breeds of cattle are preferred because they are adequate for local farm and homestead operations, could be housed within the limited homestead space, and can be easily managed by women and children. Farmers who artificially inseminate their cows do so mainly to obtain a good price for the offspring to be sold for meat. Its only the large farmers who prefer artificial insemination.

Constraints to cattle rearing are the high initial capital outlay, adverse impact on farmer economy in case of theft or death, damage caused to owners and neighbors’' crops, low rate of reproduction, and acute veterinary and health care problems.

The pros and cons that apply to cattle generally apply to buffaloes. Besides, they tolerate more adverse environmental conditions and need no special housing. They consume more fodder and the capital outlay (animal value) is the highest. An unfortunate feature is that most male buffaloes are castrated and stud buffaloes are not readily available. Buffalo milk and meat is least preferred. A major constraint at the site is the limited space for wallowing.

Goat milk is considered to be more nutritious having medicinal properties, especially good for children, and mutton is the most preferred meat. Goat urine and faces are believed to be the best manure. Housing for goats is less elaborate and inexpensive. Kids are invariably household pets and are tended, by children. Goats are also preferred from the fecundity and growth rate point of view. They damage rice crops during the early and maturity stages, but if let into rice fields, especially row sown or row transplanted fields, they would mostly nibble away the weeds selectively.

Poultry is the most preferred livestock among all farmer groups providing rapid returns to low investment and, most important of all, providing an evenly distributed cash flow. Only local birds are reared at the site. Poultry meat comes next to mutton in order of preference. They predate on a wide range of insect pests. However, there are several constraints too. They stray unnoticed into neighboring homesteads and into nearby fields causing damage to a wide range of crops often resulting in quarrels among farmers. They are the most vulnerable to disease epidemics and predators. Among exotic breeds, the Rhode Island Red is the most adoptable and blends best with the local- environment.

Though ducks have the maximum plus points, their stock is restricted at the FSR site because of the low water table and inadequate number of ponds. They are vulnerable only to one disease, the duck plague. They are very docile and do not stray away from the homestead or ponds. Eggs are laid in their cages at night and thus easily retrieve.

Pigeons feed far away from their homes. Though this entails no expenditure, it exposes them to theft and they are sometimes poisoned by irate farmers whose seed beds and grain craps are damaged. They are the least affected by diseases.

In a survey conducted in April, 1986, at the FSR site, 50 farmers were included in the survey - 10 each from the landless category (owning or renting the homestead only), marginal category (owning upto 0.20 ha of land), small category (owning between 0.21 and 1.0 ha of land). Medium category (owning 1.01 to 2.0 ha of land) and large category (owning above 2.0 ha of land).

For each farmer category, the mean number of family members and homestead area, total livestock owned, livestock owned per family member, and livestock owned per hectare of homestead land are given in Tables 1, 2, 3, and 4, respectively.

Table 1: Number of family members and area of homestead for each farmer category.

Farmer* category	Total number of family members	Area (ha)
Landless	5.8	0.040
Marginal	6.1	0.032
Small	5.6	0.057
Medium	6.9	0.101
Large	11.8	0.117
All categories	7.2	0.069

*Landless – owning or renting homestead only. Marginal – owns up to 0.2 ha of land. Small – owns 0.21 – 1.0 ha. Medium – owns 1.01 – 2.0 ha. Large – owns more than 2.0 ha.

Table 2: Livestock owned by different farmer categories.

Farmer category	Number of animals					
	Cattle	Buffalo	Goat	Poultry	Duck	Pigeon
Landless	0.8	0	0.8	8.1	0.4	0
Marginal	1.4	0	1.8	10.2	1.1	0
Small	1.5	0	1.6	8.5	0.3	0.4
Medium	1.7	0.5	1.9	12.7	3.2	1.0
Large	2.6	1.4	1.8	15.1	1.3	4.0
All categories	1.6	0.4	1.6	10.9	1.3	1.1

Table 3. Livestock owned per family member by different farmer categories.

Farmer category	Number of animals					
	Cattle	Buffalo	Goat	Poultry	Duck	Pigeon
Landless	0.1	0	0.1	1.4	0.1	0
Marginal	0.2	0	0.3	1.7	0.2	0
Small	0.3	0	0.3	1.5	0.1	0.1
Medium	0.3	0.1	0.3	1.8	0.5	0.1
Large	0.2	0.1	0.2	1.3	0.1	0.3
All categories	0.2	0.05	0.2	1.5	0.2	0.2

Table 4: Livestock owned per hectare of homestead land by different farmer categories.

Farmer category	Number of animals					
	Cattle	Buffalo	Goat	Poultry	Duck	Pigeon
Landless	20	0	20	203	10	0
Marginal	44	0	56	319	34	0
Small	26	0	28	149	5	7
Medium	17	5	19	126	32	10
Large	22	12	15	129	11	34
All categories	23	6	23	158	18	16

The number of family members and homestead area increases with farm size. Overall, the number of poultry owned is the highest while the number of buffaloes were negligible (landless, marginal and small farmers not owning any buffaloes). Landless and marginal farmers do not also own any pigeon. Considering the number of livestock irrespective of family size or homestead area, the number of cattle increases with farm size; the number of goats owned do not appreciably differ according to farmer category; the number of poultry owned generally increases with farm size; no particular trend is discernible in respect of ducks.

However, on the basis of number of livestock owned per family member, the distribution of cattle do not appreciably differ according to farm size; goats and poultry are more popular among marginal, small and medium farmers.

On the basis of livestock owned per hectare of homestead land, the number of cattle owned by marginal farmers are appreciably more; goats and poultry tend to be again popular among the smaller categories; the number of poultry is substantially high among the landless and marginal farmers.

Very few publications exist in respect of the aspects discussed in this paper. However, there is general agreement with findings of other researchers. The crucial role played by women in homestead enterprises is being increasingly recognized by FSR scientists. Saadullah (8) reported that the number of goats were the highest among. the landless and farmers owning up to 0.5 acre of land, and that the goat population increased in these groups between 1979 and 1984 while there was a reduction in the population during the corresponding period in groups owning more than 2 acres of land; among goats, cows, young stock and bullocks, he found that the number of goats was the highest in the 0 to 0.5 acre group. Magor (4) determined that 75 percent of the village chickens, ducks and goats were held by small farmers; the percentage of cows used for ploughing increased as the land owned decreased.

Improvement of cattle nutrition should receive the highest priority and, urea and alkali treated straw would improve nutrition, preserve straw and would be a practice adoptable by all farmer categories (6,8). There is limited scope to improve cattle by genetic upgrading (1,7).

HOMESTEAD CROPS AND TREES

A wide range of annual, semi perennial and perennial crops and trees are grown in and around the homestead (for food, feed and fuel). Brinjal, cabbage, cauliflower, amaranthus, beans and gourds are damaged by livestock at all stages of growth. Onion, garlic, aroids, bitter gourd, tumeric, ginger, bamboo, pineapple, sugarcane, margosa, jikka, mandar, tamarind, woodapple, lemon, pomello and drumstick are not damaged by livestock. Tomato, chickpea (pods) and chillie (pods) are damaged only

at maturity by poultry. Papaya, jak, guava, mango and banana are damaged by cattle and goats at the early stages of growth but not damaged by poultry. The farmers believe that plants damaged by goats are "poisoned" and have the least chances of survival.

Anona, wood apple and elephant apple are not damaged by cattle. Trees propagated by grafts and cuttings, taller the better (example, drumstick) so that livestock cannot reach the leaves, are less prone to damage. Quick growing crops and trees have better chances of survival as the period of vulnerability to livestock damage is shorter.

While poultry damage young succulent plants and fruits within their reach (pods on tall perennial chili plants are less prone to damage, for example), ducks do not feed on leaves and fruits. While only cattle manure is used for field crops, manure from cattle and other livestock are applied to homestead crops. Except for cattle, and goats to a limited extent, all other livestock scavenge on homestead and household residues and wastes, and rarely any expenditure is incurred in feeding them.

Crops and trees vulnerable to livestock damage, if grown, are protected by cages or barriers. Pineapple is grown around vegetable beds to prevent livestock reaching them. Pineapple and aroids are grown around cattle sheds as they are the least vulnerable to damage and so that they will be benefited by the water, dung and urine from the sheds.

Crops and trees that are not damaged by livestock have protective mechanisms such as pubescence (tomato), repulsive taste (margosa) and spines (lime).

A classic example is the protective mechanism characteristic of the bamboo tree which is a common tree in homesteads all over Bangladesh. The tree has been selected to co-exist in the homestead and to be used for many purposes - leaves for feeding cattle, as a wind break, in construction of swellings, basket making, fencing, stakes to support crops and for making furniture. The protective mechanism it has is that at the early stages of growth the leaves do not protrude out of the leaf sheaths which are dry and leathery and have a pointed tip.

The crops and trees in the homestead are also shade tolerant.

STRATEGIES FOR RESEARCH AND DEVELOPMENT

From the foregoing discussion, it is clear that the choice and management of livestock, and homestead crops and trees is governed by factors intrinsic to these enterprises. Farmer beliefs and practices have evolved out of generations of sound experience. Therefore, we have to manipulate research and development efforts within the existing framework, linkages and resources. Any attempt to improve these enterprises must be considered in this perspective.

Goats, poultry and cattle should be given priority in livestock research and development. There is limited scope for livestock improvement by genetic upgrading using exotic breeds, except in poultry. If undertaken, it could even have disastrous consequences. The best strategies would be to improve nutrition by methods such as urea treated straw and emphasizing biomass production in crop research, and improving health and veterinary care.

Ecospecific factors like the limited scope for duck rearing at the Jamalpur FSR site should be taken into account.

The target crops and trees in homesteads should be the various fruit trees, vegetables, yams, spices, and timber species - there is a variety of them - that co-exist in the homestead environment.

In Bangladesh, there is no possibility of absorbing excess and underutilized labour into industry. Therefore, the onus of rural development is entirely on Agriculture. Farmers are circumscribed by agro-ecological and socio-economic factors and enterprises adopted by them are not susceptible to revolutionary changes. This is the challenge to researchers and extensionists - to select the right target crops and livestock genera , breed appropriate varieties of crops and work on the most urgent and appropriate livestock and homestead crop and tree management systems without disturbing the existing linkages.

ACKNOWLEDGEMENT

Mere are indebted to Messrs. Habibur Rahman, Ahsan Habib and Saiful Islam, Junior Scientific Assistants, for all assistance at the FSR site regarding these studies. Some of the information presented in this paper emerged from case studies which were initiated and directed by Dr. Anil Gupta, FSR Consultant, Ford Foundation, and Dr. Zainul Abedin, Chief Scientific Officer, On-Farm Research Division, Bangladesh Agricultural Research Institute.

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PADDY, NAPIER AND MILK CATTLE : A FARMING SYSTEM IN A DROUGHT PRONE AREA OF SOUTHERN INDIA

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Introduction

Chittoor, a drought prone district of southern India is situated between 14° - 37" and 14° - 8" of North Latitude and 78° - 33" and 79° - 55" of the Eastern Longitude. The total area of the district is 15,152 sq.km., with a population of 27.47 lakhs. The agricultural senario is marked by smaller land holdings. Of the total 1.63 lakhs holdings, 50.81 per cent are less than one ha. and 25.73 per cent are just over two ha. in size.

The district receives an average rainfall of 828 mm and the major source of irrigation is tubewells. The recharge of water from the wells is however limited, hardly sufficient for cultivation of 1 to 1.5 ha. Soils are mostly red, loamy and sandy type, paddy and groundnut are the principal crops.

With a population of 1.95 lakh milch animals the district accounts for about half a million tonne of milk annually, a fifth of that produced in Andhra Pradesh (a state in South India Chittoor is located in) . Government intervention in the form of an aggressive crossbreeding program and establishment of a milk product factory gave fillip to the milk production. Majority of the farmers keep crossbred cows (Jersey x Punganur) which form an integral part of the farming system. Wage employment for a period of 4-6 months an year comprises another important source of income for the small/marginal farmers.

The objective of this paper is to highlight the integrative nature of the existing farming system and the subsystem interactions between crop, livestock and wage employment. The sub-component nexus within the overall framework is examined in the light of complimentary/competitive nature of labor absorption, income accrual and food and feed supply.

Materials and Methods

The data based on a field study of five farmers are collected in three rounds during the year 1985-86. The selection of the respondents was purposive and the data collected through structured schedules. The findings however, are preliminary and are a part of a long term FSR project.

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Results and discussion

Socio-economic Component

The mean land holding is 1.17 ha. Of this 1 ha. Is under paddy and 0.17 ha. under Napier grass. Two crops of paddy are taken in an year while the napier is taken on a separate strip as a perennial crop. An open well with a capacity to irrigate 1.5 ha. is the sole source of water. The average animal holding size is 8, all crossbred cattle, of which 2.5 are in milk 2.5 dry and the remaining young stock. The average family size of the farmers is 5.33, 2.00 are workers and 3.33 dependants.

Source of labor

The data compiled in Table 1 indicate the spread of the 'family' and 'hired' labor. Of the total mandays deployed, 84.74 per cent are from the 'family' while only 15.26 per cent are 'hired'. It is to be noted that all the hired labor is absorbed in crop agriculture.

The data pertaining to the break up of labor absorption among the three enterprises; crop agriculture, animal agriculture and off-farm* are presented in Table 2.

Maximum labor, 35.88 per cent is deployed in animal' agriculture followed by 34.64 per cent in off-farm work and 29.48 per cent, crop agriculture. The labor absorption period for paddy I is from July-November while for paddy II, November-March. About 70 per cent of the labor input for crop agriculture is hired. This is because of the labor intensive nature of agricultural operations at a few given points of time.

As of animal rearing, all the labor input for: cleaning the animals and shed, cutting and feeding the fodder, milking and marketing: is met by family. The animal agriculture unlike the crop agriculture is labor distributive in more than one sense. Firstly, the labor input is more or less even throughout the year and that all the family members including children can meet the labor needs (Table 3).
Regarding wage employment more than half of it (54 per cent) occurs in three months, July, October and November while the remaining is spread across the nine other months.

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* throughout the text crop/livestock activities are referred to as on farm and wage employment as off-farm.

Taking into consideration all the activities, the busiest month, in fact, is November followed by July and October (Fig.i). That farmers are more busy in these three months is due mainly to the fact that besides the work on their farms they also work on fields of other farmers as 'exchange labor' — an age old institutional arrangement -- practiced to cope with the agricultural labor demands.

Production and income

The production and income data of on-farm enterprises are presented in Table 4. The net income from crop agriculture is Rs.8010 which is about 20 per cent more than that from the sale of milk. While both crop and livestock production are based on improved germ plasm, productivity of labor and capital is higher in crop than in animal agriculture.

Coming to the income spread (Table 5), the crop income accrues at four points viz., March, May, August and December. As per the harvest schedule the grain is collected only twice, December and April, but it is sold in four installments as per the liquidity needs of the family, The animal income, however, is more evenly spread giving edge over the crop income flow pattern. It is for this reason, it finds a place in the farming system.

The total cash inflow and outflow (Fig.2) trends indicate that March, May, April and December are the main months for cash inflow while the cash outflow is relatively even except that is at the highest (Rs.670)* in July.

Thus the total income of the family is Rs.15,250 ($ 1272). Of this 52.50 per cent is contributed by crop, 41.99 per cent by animals and 5.51 per cent, off-farm work.

Crop livestock interactions

The contribution of animals to crops in the present context is through supply of 11 tones of manure which accounts for 16.29 per cent of the value of agricultural inputs. The traction requirements of agriculture are, however, met by a hired tractor. This is the main reason that the animal subsystem is represented in the form of a pure milch herd.

The crop component, in turn, accounts for 88.22 per cent of dry matter consumed by the bovines, 55.56 per cent of Digestible Crude Protein (DCP) and 85.29 per cent of Total Digestible Nutrients (TDN) (Table 6). In other words, the farmers obtain only the protein supplements through out-of-pocket expenses to meet the milk production.

*Rupees

It is interesting to note though crop and animal components are managed through improved technology the nexus between the two of them remained intact.

Farm off-farm interactions

While the use of wage income for purchasing crop and livestock inputs is obvious there are other less tangible interactions through which the off-farm component of the system supplements the two other components, crop and livestock. Firstly, when farmers go to work on other farms for wage employment they are allowed access to the green fodder as part of their wage. This amounts to a total of approximately 0.50 ton of fodder on fresh weight basis which accounts for seven per cent of the green fodder fed to the animals. Secondly, about 30 per cent of the mandays absorbed in the off-farm activity go towards' exchange labor' and not for income per se. This institution would help the farmer, as noted, to cope with the labor demand in the acute agricultural season.

Paddv-Naoier-milk cattle system, an overview

It is well known that farmers, particularly the poor in the developing countries, allocate the factors of production - land labor and capital - to three productive processes namely crop, livestock and off-farm to meet multiple goals like ensured food supply, cash income, leisure, prestige etc. consistent with the socio-institutional environment they are in (Norman,1983; Clayton,1983).

In the present context the vagaries of monsoon, limited recharge of water from the tubewell and availability of dairy marketing infrastructure led the farmers adopt a paddy-napier milk cattle system.

The system is diversified enough to yield both food and feed on the one hand and to provide insurance against uncertainties of income generation and gainful employment, on the other. It also reflects the allocative wisdom and rational decision making prowess of the farmer in response to opportunities and constraints (Schultz,1964).

The crop component besides providing cash income ensures him 1.50 ton of staple food and majority of the feed for his livestock. The animal component obliged him by giving protective food like milk (300 lit) and cash income. The off-farm component supported the crop/livestock: activities and supplemented his cash income.

The diversified product line and the temporal 'spread' of activities and cash flows, the system entails to the best advantage of the farming family, belies its apparent simplicity. It warrants a trans-disciplinary perspective for its comprehension and for designing interventions to further its productivity.

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Table 1

Source of labor across Calendar Year

Month	Family (a)	Hired (b)	Total (a+b)
Jan	26 (6.33)	--	26 (5.36)
Feb	28 (6.81)	8 (10.81)	36 (5.36)
March	31 (7.54)	8 (10.81)	39 (8.04)
April	28 (6.81)	--	28 (5.77)
May	30 (7.30)	--	30 (6.19)
June	23 (5.60)	1 (1.35)	24 (4.95)
July	56 (13.63)	19 (25.68)	75 (15.46)
August	43 (10.46)	--	43 (8.87)
September	22 (5.35)	2 (2.70)	24 (4.95)
Oct	45 (10.95)	14 (18.92)	59 (12.16)
Nov	56 (13.63)	22 (29.73)	78 (16.08)
Dec	23 (5.60)	--	23 (4.74)
Total	411(100.00)	74(100.00)	485(100.00)

Table 2

Labor utilization across enterprises

Month	Enterprises: Crop: Paddy I	Crop: Paddy II	Crop: Fodder	Animal	Off-farm (wage employment)	Total	Activities
Jan	--	3(13.04)	5 (21.74)	13 (56.52)	5(21.74)	23(100.00)	Weeding, land preparation, sowing for fodder crop
Feb	--	9(25.00)	2 (5.56)	15 (41.67)	10 (27.78)	36(100.00)	Harvesting
Mar	--	10(25.64)	2 (5.13)	15 (38.46)	12 (30.77)	39(100.00)	Threshing
April	--	--	2 (7.14)	15 (53.71)	11 (39.29)	28(100.00)	Fodder cutting
May	--	--	5 (16.67)	15 (50.00)	10 (33.33)	30(100.00)	Fodder cutting
June	1 (4.16)	--	4 (16.67)	15 (62.50)	4 (16.67)	24(100.00)	Land preparation, seedbed preparation
July	25 (33.33)	--	3 (4.00)	15 (20.00)	32 (42.67)	75(100.00)	Transplantation
Aug	8 (18.60)	--	3 (6.98)	15 (34.86)	17 (39.52)	43(100.00)	1st weeding
Sep	2 (8.33)	--	3 (12.50)	15 (62.50)	4 (16.67)	24(100.00)	2nd Weeding
Oct	15 (25.42)	--	3 (5.08)	15 (25.42)	26 (44.07)	59(100.00)	Harvesting and threshing, seedbed preparation
Nov	--	28(35.90)	2 (2.56)	13 (16.67)	35(44.87)	78(100.00)	Puddling and transplantation
Dec	--	5(21.74)	3 (13.04)	13 (56.52)	2 (8.70)	23(100.00)	Fertilizer application, weeding
Total	51 (10.52)	55(11.34)	37 (7.63)	174(35.87)	168 (34.64)	485(100.00)	

Table 3

Labor Distribution among family members

Mandays	Crop	Animal	Wage employment
Man	36 (33.96)	42 (24.14)	92 (54.76)
Woman	65 (61.32)	85 (48.85)	76 (45.24)
Children	5 (4.72)	47 (27.01)	--
Total	106(100.00)	174 (100.00)	168 (100.00)

(Figures in parentheses are percentages)

Table 4

Production and income for crop livestock components

Particulars		Paddy I	Paddy II	Milk
(i)	Yield per year (kg)	3033	3246	3725
(ii)	Cash expenditure (Rs)	1225	1449	2755
(iii)	Cash income (Rs)	5156	5528	9163
(iv)	Profit (iii-ii)	3931	4079	6408
(v)	Cash income/expenditure ratio	4.23	3.81	3.33
(vi)	Profit per labor day	77.08	74.16	36.83
(vii)	Profit per Rs.100 of expenditure	320.90	281.50	232.60

Table 5

Income accrual across Calendar Year (in Rs.)

Enterprise	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Crop													
Expenditure	195	270	280	220	--	220	410	150	225	250	190	264	2674
Income	--	--	1956	--	1750	--	--	2918	--	--	--	4060	10684
Animal													
Expenditure	305	210	150	125	125	105	260	325	240	270	300	340	2755
Income	905	620	423	240	270	420	850	875	900	1160	1240	1260	9163
Off-farm													
Expenditure	--	--	--	--	--	--	--	--	--	--	--	--	--
Income	25	42	74	55	47	20	135	65	26	122	219	10	840

Table 6

Crop contribution in animal nutrition[1,2,3]

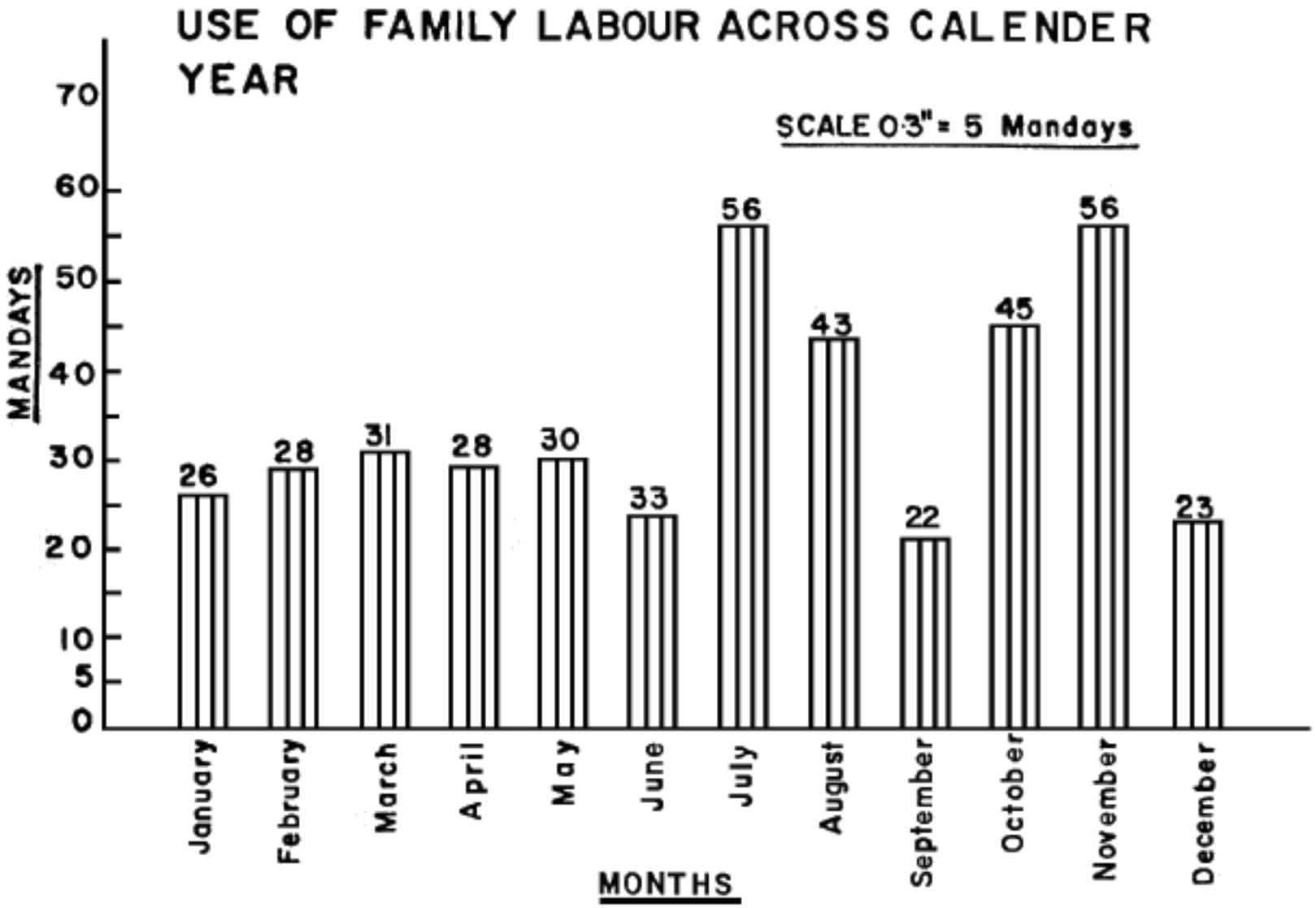
Nutrients	Straw	Green fodder	Concentrates (Rice Bran)	Total	% input from crop
DM (Tonnes)	10.05	7.50	2.30	19.85	88.22
DCP (Quintals)	0.00	3.80	3.40	7.20	55.56
TDN (Quintals)	40.20	45.00	16.80	102.00	85.29

1. Calculated on the basis of 25 percent Dry Matter, 1 percent DCP and 17 percent TDN for Napier on Fresh basis.

2. Zero DCP and 40 percent TDN for Rice Straw.

3. 5 percent DCP and 55 percent TDN for Rice bran.

Fig. I


USE OF FAMILY LABOUR ACROSS CALENDER YEAR
SCALE 0·3" = 5 Mandays
MANDAYS
70
60
50
40
30
20
10
5
0
26
28
31
28
30
33
56
43
22
45
56
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January
February
March
April
May
June
July
August
September
October
November
December
MONTHS

Fig. 2

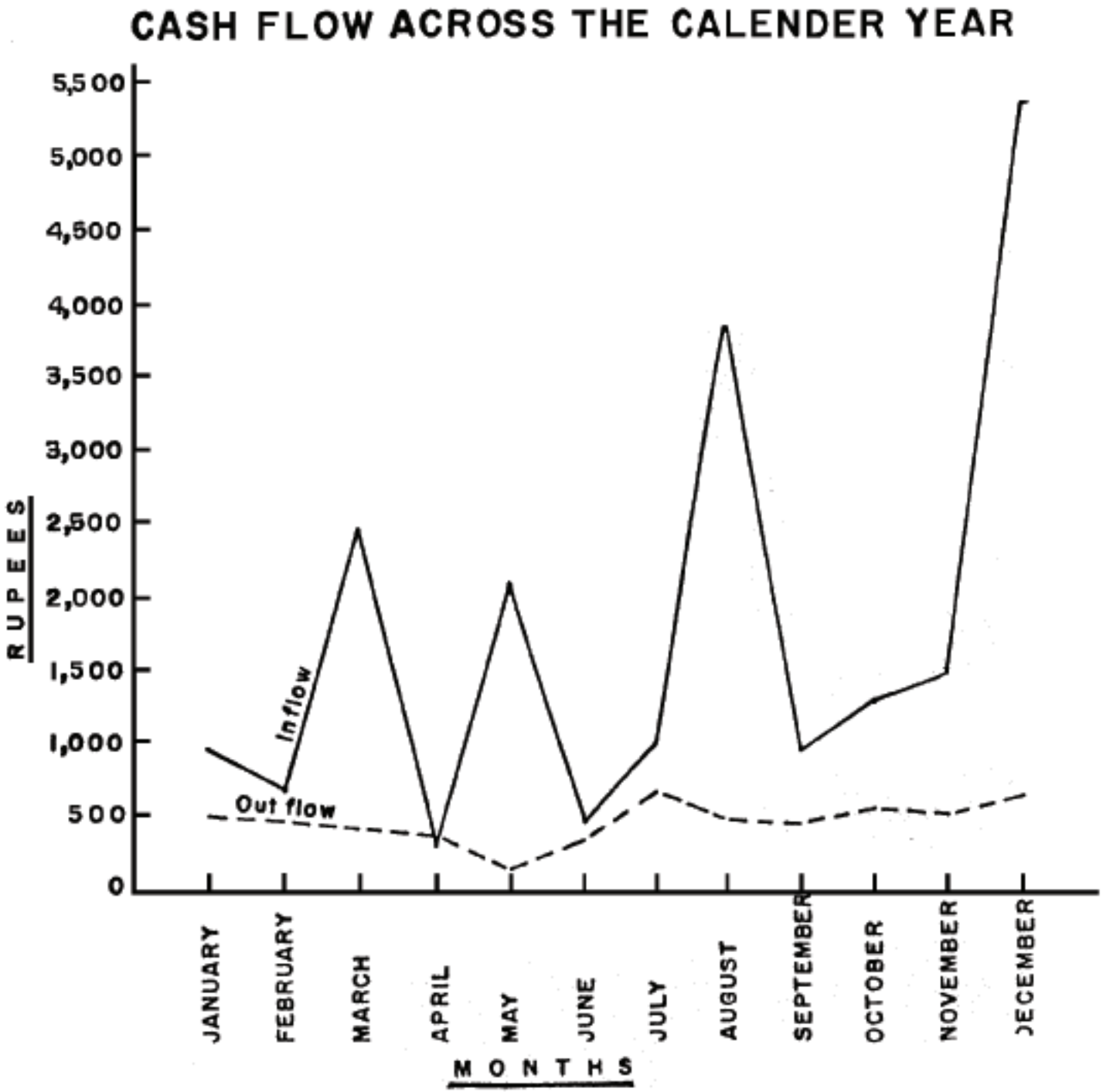
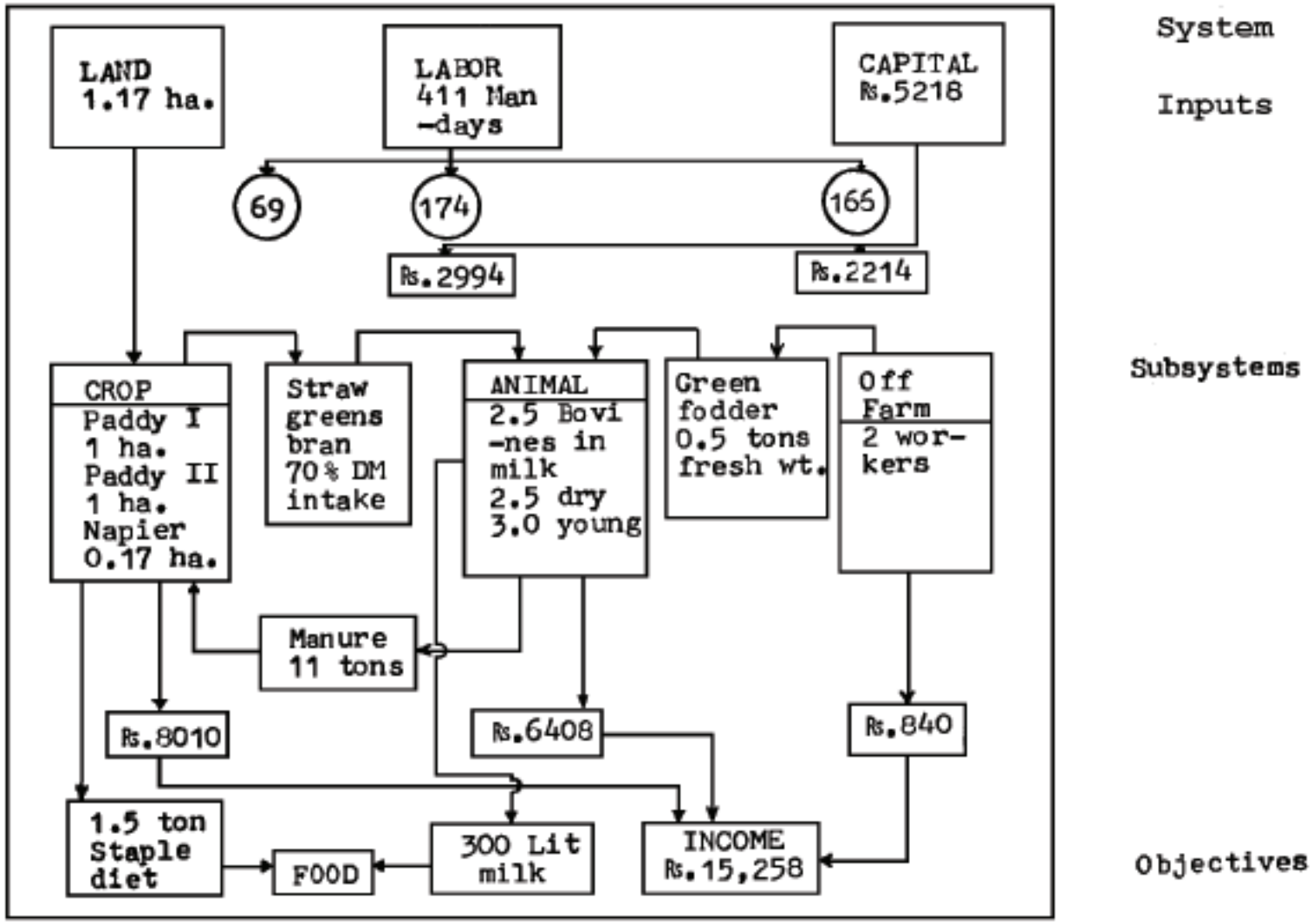

CASH FLOW ACROSS THE CALENDER YEAR
RUPEES
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Inflow
Out flow
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
MONTHS

Figure: 3. Crop animal off-farm interactions



MARKET INTERACTIONS OF SELECT BAGGARA TRANSHUMANTS DURING DROUGHT AND POST DROUGHT PERIODS: THE CASE OF SOUTH KORDOFAN, SUDAN IN 1985*

INTRODUCTION:

Location:

The Baggara (cattle owning people) transhumants (migratory along fixed routes) of Sudan, Africa migrate along routes crossing the Southern Kordofan Province and entering the Northern Kordofan Province of the country. Southern Kordofan Province is located between 9 degrees and 13 degrees North Latitude and 27 degrees and 33 degrees East Longitude. Figure 1 presents a map showing political boundaries and locations of major towns, some of which are referred to in the report.

A research program was undertaken during the late dry season and late rainy season of 1985 by the Western Sudan Agricultural Research Project (WSARP) using the Kadugli Research Station of the WSARP as headquarters for the study. Kadugli, Sudan is the provincial capital of Southern Kordofan and is located at 11 degrees 0 minutes North latitude between 29 and 30 degrees East longitude. The program area extends from approximately 35 kilometers NW of Kadugli to 180 kilometer NE of Kadugli; an area which follows routes normally used by the transhumants.

Environment:

Southern Kordofan Province of Sudan encompasses several climatically different environments associated with differences in latitude, longitude and elevation. The peoples described in this report traverse the entirety of Southern Kordofan Province and therefore move through many different ecological zones.

The province is located within the Sudan-Sahelian savanna zone. Altitude varies from over 1000 meters in the Nuba Mountains, located in the central and Southern area of the province, to less than 500 meters above sea level in the plains areas. The Southern part of the province is characterized by undulating plains broken by the Nuba Mountains which outcrop across the area. As one moves North the plains become more prevalent and the topography more homogenous as a result.

Due to rainfall patterns the vegetation of the southern part of the province is quite different from that of the North as is the ecology of the mountains. Moving from South to North the transhumant would traverse areas characterized by woodland savanna at the intensive margin followed by semi-desert areas at the extensive margin for cattle, sheep and goat production.

The Baggara transhumants begin their migration at the intensive margin for livestock production in the South and move toward the extensive margin in the North during the rainy season. At the end of the rainy season they retrace their initial routes to an area twenty to thirty-five kilometers South of the point where they will eventually stay during the dry season.

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Temperature:

Long term temperatures for the Southern part of the province vary from a minimum of about 18 degrees centigrade in January to over 40 degrees centigrade in March and April. Mean temperatures range from a low of 27 degrees to a high of around 31 degrees centigrade. In the Northern areas the temperature is somewhat higher with the mean temperature ranging from a low of 18 degrees to a high of 33 degrees centigrade.

Precipitation:

Rainfall, both effective and total, is highly variable across years and across space. The long term average rainfall for El Obeid, which boarders the Northern migratory return point, is 386.0 mm. compared with 732.0 mm. for Kadugli at the Southern fringe. Figure 2 presents long term mean annual rainfall for both Kadugli and El Obeid.

Soil:

Soil structures vary over the transhumant migratory routes. Dark brown, deep cracking clays are the most extensive soils in the the Southern Nuba Mountains area. These soils, also referred to as cotton soils, are similar in structure, texture and physical characteristics to vertisols which were classified by Buol, (1980). Hunting Technical Service (1976) refer to these soil as predominantly alluvial in origin and similar to alkaline vertisols.

A second major soil type in the area is the Gardud soil. This soil is a medium to heavy textured alluvial soil. Textures range from loam and clay loam in the top 50 cm. to sandy clay loam, sandy clay and clay in the subsoil (HTS, 1976).

The third major soil type of importance to the Baggara is the Qoz sandy soil. These soils are yellowish red sands, loamy sands, and sandy loams which are acid in reaction and low in all macro and micro nutrients (HTS, 1976). The Qoz soils, due to their rapid drainage, provide a suitable soil for the transhumants to camp upon during the rainy season. These soils are more prevalent in the Northern parts of Southern Kordofan Province.

Socioeconomic:

The Baggara transhumant production system of South Kordofan Province in Sudan has been a major source of livestock production for Sudan over the years. Many different groups may be aggregated under the heading "Baggara" including sub categories of peoples which might include the Humr, Messirriya, Felleta, and many individuals from Nuba tribes. Traditionally the word Baggara has been used to denote Arab cattle owning transhumant or nomadic individuals and groups. Baggara may also be used to denote Nuba or other peoples who have shifted from sedentary production activities to transhumance.

The Hawazma and Messiriya now occupy the central part of South Kordofan. These two gabily (tribes) are Arab transhumants while individuals from another group of people called the Nuba are non Arab.

The Nuba participants are dissimilar in cultural background and generally in religious beliefs. The Nuba people occupy the mountains and cultivate the surrounding plains areas. They live in the Nuba Mountains of South Kordofan Province. While transhumance is not the major lifestyle of the Nuba, many families participate when the size of their cattle, sheep and goat herds result in the livestock enterprises becoming primary economic enterprises.

The Arab tribes are believed by some to have migrated to the Western Sudan after the Arab invasion of Egypt. Following the invasion the Arabs, which later became the Baggara, are thought to have continued their march across North Africa to what is present day Tunisia. From Tunisia they are said to have moved South into what is now considered their home territory in the Western Sudan. Others believe that the Baggara formed part of an invasion up the Nile valley at the end of the fourteenth century (Gunnison, 1966). They subsequently are believed to have migrated to areas which are now the provinces of North and South Kordofan and North and South Darfur.

The Nuba who participate in transhumance are only a small minority of the general Nuba population which is primarily involved with sedentary cultivation. The Nuba are generally considered autochthonous to the area and may have controlled larger areas of South Kordofan prior to the arrival of the Arabs (South Kordofan Planning Unit, 1978).

Cunnison (1966) provided anthropological information on one of the subgroups of the Arab Baggara known as the Humr. This study deals with economic and demographic information on another main gabily known as the Messiriya. As Cunnison (1976) points out, the Messiriya and the Humr are related closely and were once considered a single tribe. Other gabily and Nuba tribes are also represented in the work and will be distinguished when differences may create a degree of heterogeneity which requires explanation.

Nature of Production System:

Abu Sabah (1985) has characterized a Messiriya sub-tribe called the Inainat as a "bovine culture". This characterization may be equally applied across other transhumant tribes for the purposes of this paper.

He goes on to say the following:

> "Within this culture the general trend of accumulation of wealth through accumulating cattle, and with them, prestige, political, and social influence occurs. In addition to cattle, sheep and goats are also reared as are fewer numbers of chickens, donkey, and very occasionally camels, which are usually purchased as adults for beasts of burden. The primary

> characteristics of this target group are: a) a primary production enterprise consisting of the rearing of cattle with average herds greater than 50 head; b) limited cropping activities; and c) seasonal migrations along relatively fixed routes between South and North Kordofan grazing areas."

The production cycle encompasses the birth, rearing, sale and consumption of livestock and livestock products supplemented by grains both produced by the household and purchased in the market. The Arab Baggara will generally depend upon livestock for food and income to purchase other staples to a greater extent than the Nuba Baggara. However, the designation of a Nuba household as a Baggara household implies that primary production activities are centered around the ownership of livestock rather than the production of grain commodities.

Baggara transhumants produce livestock, mainly cattle, sheep and goats, in an area of Sudan which encompasses potential for both intensive and extensive production characteristics. The Baggara migrate to provide a source of food and water, protection against disease, insects and mud and for marketing of livestock. A wide spectrum exists with respect to household cattle, sheep and goat holdings, with some households controlling in excess of several hundred cattle. The proportion of small ruminants to cattle in the system is approximately 2:3. Demographics of traditional herds show that a relatively high proportion of male to female animals exist within cattle herds at ages over thirty months, approximately a 3:1 ratio (1985). Bunderson (1985) has estimated a female to male ratio in sheep herds of 3.7:1 in a Baggara herd. No similar information is available for the ratio of female to male animals in goat herds among the Baggara although they are an important hedge against environmental risk.

RESEARCH PROGRAM OBJECTIVES AND DETAILS:

During 1985, the Socioeconomic section in conjunction with the Range/Livestock section of the Kadugli Research Station undertook a two phase survey to provide baseline economic and demographic information on the Baggara transhumants. A general objective of the program was the provision of marketing information for the WSARF technical assistance team. This report draws together part of the results of that study and integrates those with livestock and commodity price information which had been collected during the same periods in different markets.

The specific objectives of this paper are the following:

1. Document the trends in prices at the sub-regional and regional marketing levels to measure price differentials which existed across space for both livestock and non livestock staple food commodities;
2. Use the information developed in objective 1, in combination with other primary data, to describe the effects on nutritional levels in Baggara transhumant households resulting from loss of purchasing power; and
3. Identify a method of and time for intervention in the production system which would result in the maintenance of purchasing power without increasing market risk.

EXPERIMENTAL DESIGN:

A two phase enumeration schedule was developed. The first phase of the enumeration took place in April and May of 1985. This represents the late dry season in South Kordofan Province. The site of the experiment during this phase was Demick, Sudan. Demick represents a subregional market town with a periodic market occurring on Saturday and Tuesday each week. A second important factor in site selection was the importance of conducting research in areas where the Range/Livestock section had ongoing experiments. A third factor entering the decision on choice of site was the homogeneity of market participants. Demick market was frequented by many different tribes of Nuba and Baggara Arabs. The predominant tribe was the Messiriya.

During 1985 a severe drought occurred and resulted in more pronounced market price movements which impacted upon the households ability to purchase staple foods. For the Baggara household this resulted in decreased capability to purchase basic food requirements. However, for the purposes of this paper, the drought can be seen as an extreme case of the seasonal impact of fluctuating prices which are the norm rather than the exception. In this context the drought provided opportunities for developing a data base which allows a more graphic picture of the predicaments facing the transhumant household on a yearly basis.

Enumeration of all individuals in the market who were selling or purchasing livestock was attempted. The first enumeration took place on Saturday, March 20, 1985 and was continued, on a weekly basis, through May 12, 1985. During that time eighty-eight interviews took place. The number of enumerations was a function of activity in the market and the problems encountered defining a sample frame and subsequent inability to sample the population in a structured manner. It was and is logistically impossible to identify all individuals who might participate in marketing or the purchase of livestock in Demick on any given day or over any given period. The author estimates that enumerations as a ratio to actual transactions in the market was approximately .85:1. This was based upon observation of market activities and consultation with staff familiar with livestock marketing in the area.

The survey questionnaire consisted of twenty-five questions with multiple parts. Questions included in the phase one questionnaire were directed primarily toward the market activity which had occurred just prior to enumeration and the most recent previous market activity.

The second phase of the survey was undertaken during the late rainy season when the transhumants were at or near their Northern most point of the migratory route. Thirty-five producers were interviewed during this phase of the survey. Every attempt was made to identify and enumerate producers who had been enumerated during phase one of the survey. However, this turned out to be impossible due to logistical considerations. Producers were located in areas which were inaccessible, could not be located due to remoteness of the area and were located in different fariques (camping groups) to numerous to track down with limited time and resources available to the enumeration team. The team was forced to

interview members of fariques which were accessible and came from the same general area around Demick. It is the position of the author that those enumerated during phase two were representative of the recommendation domain targeted in phase one of the enumeration program.

The second phase emphasized question pertaining to the marketing activities which occurred during the rainy season while the Baggara were on their annual trek. Strategies employed by producers to maintain herd size and the composition of herds were identified as well as the demographic composition of family. Births, deaths and losses from theft or other management problems which occurred during the trek were enumerated. A section of the survey questionnaire dealt specifically with general market characteristics which were encountered by the transhumants in their marketing activities. A section was also devoted to the identification of production costs associated with each major species of livestock owned by the producer household. A final section of the survey instrument was designed to collect information on the actual transportation activity which is entailed in migration.

Market Structure:

Along the transhumant migratory routes there are villages and towns where they market livestock and livestock products and purchase commodities for household consumption. Movements on a yearly basis are defined by the onset of rains in the South and lack of water sources or graze in the North. The information on the left of the Figure 3 represents a typical migratory route.

The body of Figure 3 presents the flow of commodities in the livestock market. The market structure within which the transhumants operate is such that poor flow of information may restrict their ability to take advantage of financial opportunities which arise at different levels of the market. (All communication outside the major villages and towns is done by word of mouth or carried note.) At the lowest level of the market are the producers who rear livestock for sale, consumption and as a store of value. These animals are sold when a need arises with the money income generated used for a variety of purposes. At the next level, the subregional level, periodic markets operate weekly or more often but not daily. Most transhumant marketing occurs at this level. The regional level is characterized by permanent markets such as that which exists in Kadugli. Livestock purchased for resale in the Kadugli market may be transported to the national markets for consumption in urban centers or for export on the international market. Examples of these markets would be Khartoum, Kosti, and El Obeid.

A few large merchants will assemble herds at the regional level and transport the livestock overland, by rail or by truck to the national markets. In general the transhumants are not involved at this level. One result of this is that new innovations or technologies which are in use at higher level markets are not disseminated at regional or subregional levels. It probable that demand for goods and services with the resultant increase in off-take would be greater if the Baggara had direct access to these markets.

Market Conduct:

The market for both livestock and non livestock commodities at both subregional and regional levels is characterized by strong competition on the supply side and potential oligopsony during part of the year on the demand side. It is not clear whether the conduct in the livestock market on the buyers' behalf lead to price distortions. However, in the staple grain markets it appears that normal profits exist for the few merchants trading in the Kadugli market and in smaller sub regional markets. (Speece, 1985). Table 1 provides markups on the staple food, sorghum, in five different villages located in the area around Kadugli, Sudan.

Figure 4 provides maximum profit margins of channel participants in sorghum marketing with the Kadugli wholesaler as final demand. The markups and the profits margins support the conclusion about normal profits. This conclusion may be applied to other regional markets. Subregional markets may have a higher propensity toward oligopsony or monopsony due to fewer traders and seasonality of commodity transaction activity but show little inclination toward exorbitant markups.

Market Performance:

Based on the level of competition which appears to exist in both livestock and non livestock commodity markets which are frequented by Baggara transhumants, market performance is fairly efficient. The transhumants' tribe may in many cases have a permanent agent assigned to a livestock market. The agent would provide market information and act as a conduit for communication among potential buyers and sellers. While the agent is typically in business for himself (exclusively a male dominated activity) he will represent the interests of his tribe over those of others operating in the market. This tends to increase the efficiency of the market in that it provides a focal point and a degree of security for an individual entering the market to sell or purchase livestock.

This is not the case for the commodity markets. In these markets at a regional level a few sellers will be licensed to purchase and sell major staple grains in a central market area. In the Sudanese case this would generally be dura (sorghum). At certain times of the year maize and lubia (cowpeas) would also enter this market. These individuals are influenced in decisions about sales which they undertake by the price of similar products in the unlicensed market operating simultaneously. The unlicensed market is not a black market, rather it is a producers market which competes with the licensed merchants. Once again there is little opportunity for excessive profits due to competition from the producer market. During times of scarcity this competition will not exist and the environment for price fixing becomes more conducive to oligopolistic market activity. However, commodities will flow into an area from other regions during that period creating yet another buffer against price fixing. A large merchant in Kadugli felt that his net profits actually decreased during this period due to increase competition from outside (El Fhati, 1985, personal comm.) This also reflects the inelastic nature of the demand curve for certain commodities.

In both the livestock and non livestock markets at the subregional and regional level there appears to be two major impediments to increasing the efficiency within and thereby the performance of the market. These are poor transportation infrastructure and poor communications infrastructure. Other factors such as storage (very efficient at the farm level), standard grading practices and lack of an effective extension service exacerbate the problems but are not primary determinants of inefficiency in the market at the present time.

HOUSEHOLD CHARACTERISTICS:

The transhumant households enumerated during phase two of the survey consisted of husbands, wives, children, relatives and hired help referred to as cowboys. It is assumed that individuals enumerated during phase one of the survey were members of households homogenous in household characteristics with those of phase two. It is likely that the cowboy would not be part of the household during periods other than the trekking months. Table 2 provides a breakdown of family composition by category and sex.

Male children reach adulthood around the time they are 16 years of age while female children are considered adults at around 14 years of age. Cowboys are adult males but not relatives of transhumants. The mean size of the transhumant household is ten with ages ranging from less than one year to 85 years. The mean age of household members is 16 years.

Ninety-four percent of the household members accompanied the farique on the migratory trek. The other 6% maintained a residence at some other location normally so they could participate in school.

Eighty-five percent of the household members had no previous education. Approximately 1% had participated in Kalwa (Islamic religious training). Primary school had been attended by 12% of the transhumants while less than 1% had attended either secondary or high secondary educational facilities. Of the 58 individuals who had the opportunity to go to school, the mean number of years attending was 4.4 years.

MARKET TRENDS:

Figures 5, 6, and 7 present trends for cattle, sheep and goat prices over the period August 1983 to August 1985. Figure 8 presents market trends for the retail sale of sorghum, cowpeas, and sesame during the dry season and rainy season for 1984 and 1985 on a monthly basis. Wholesale price trends are presented in Figure 9. It is important to remember that during certain periods commodities may have been unavailable in the market at which times higher priced substitutes had to be purchased. This is represented by broken lines in the graphs with the exception of November and December 1985 for non livestock commodities. These breaks are due to no price information being collected. For the analysis presented below, sorghum will be considered a proxy for other grain and legume commodities.

It is clearly shown that price differentials between livestock and non livestock commodities increase during years of normal precipitation and decrease during drought stress periods. Figure 10 presents this situation

graphically and dramatically. The wholesale price of sorghum is graphed against the market price for male cattle. It can be seen that during the most extreme period of the drought related food scarcities in 1985 the price of a sack of sorghum was equal to the average sale price of an ox. This has a tremendous impact on the purchasing power of the transhumant household.

Energy and Protein Differentials:

During these periods of drought Baggara transhumants were forced to reduce herd size to maintain household consumption levels of protein and calories. The question arises as to whether the Baggara are able to reduce both environmental and market risk associated with drought conditions. The answer to this question appears to be yes but not in the absence of educational programs designed to inform the Baggara of the benefits of adopting flexible livestock sale strategies. Surprisingly, the greatest benefits with respect to maintenance of household protein and calorie levels appear to exist during normal years or the year preceding the onset of a severe drought which may lead to malnourishment or malnutrition.

Calculations of energy and protein levels associated with deteriorating terms of trade faced by the Baggara are presented in Tables 3, 4, and 5. Sorghum is used as a proxy commodity for other grain and legume crops due to its preeminence as the staple food and to simplify the analysis. Similar-trends exist with respect to other grain and legume commodities as well as to those non livestock commodities which are imported and available in regional markets such as rice and wheat flour.

Cattle meat (Zebu, the predominant breed of cattle owned by the Baggara) is used as a proxy for protein and calorie estimates lost in the sale transaction which must occur for the purchase of sorghum for household consumption. The Baggara producer has a choice as to whether the household will consume meat or sorghum or some combination. In this analysis it is assumed that the choice is mutually exclusive, the household consumes meat or sorghum. This is a plausible assumption in the real world context. The household gives up livestock to purchase sorghum, the staple commodity.

Table 3 provides information on the nominal wage price of sorghum and meat protein and calories during the 1985 pre drought and 1985/86 post drought period. Protein is given in grams of crude protein per Sudanese pound (GCP/LS) and calories are given in units of calories per Sudanese pounds (Cal./LS). The implicit assumption included here is that the Baggara prefer to maximize the availability of protein and calories during periods of drought while at the same time maintaining herd size. During the late dry season of 1985 the Baggara could purchase 67.8 GCP and 2302 Cal./LS. If they consumed male cattle meat during the same period they could purchase 88.5 GCP and 1125 Cal./LS. This period represents the pre famine period in South Kordofan province during 1985. Poor rainfall during 1984 had resulted in the narrowing of price differentials between livestock and sorghum which continued into the rainy season of 1985. By the time the rainy season of 1985 had begun late May, the Baggara's terms of trade had deteriorated to a point where the household could purchase sorghum which provided 61.6 GCP and 2091 Cal./LS or meat which provided only 63.0 GCP but

only 801 Cal./LS. In contrast, during what might be considered a normal year the Baggara household could purchase sorghum yielding 190.6 GCP and 6472 Cal./LS or meat which would yield 30.8 GCP and 391 Cal./LS as a result of decreased prices for sorghum and increasing prices for meat. This is represented by the Mid Dry Season data presented in Table 3.

This data provides a basis for the following contentions:

1. During normal years the sale of livestock during the mid dry season and the purchase of sorghum for consumption at a later date will provide more protein and calories than normal livestock sale patterns which exist among the Baggara.
2. A strategy designed to promote sales of livestock and purchase of staple commodities by the Baggara would provide opportunities to maintain household nutrient consumption levels and maintain higher disposable income levels for the Baggara. It would also decrease livestock and meat prices for urban consumers leading to increased effective demand for food at the most critical period of food shortages.
3. Educational programs designed to provide this Information to Baggara households may prove more successful in promoting sales than would price incentives offered by government agencies.
4. The strategy would be effective during both normal and abnormal rainfall years but pay greatest dividends with respect to household productivity during drought or famine periods.
5. A strategy designed to promote livestock sales during the mid dry season and purchase of grains for household consumption at the same time or some later date would do little to disrupt the production system due to the sedentary nature of the transhumants during this period.

Table A supports the contentions laid out above. The loss of purchasing power in terms of ratios of sorghum price to that of cattle meat price for protein and calories is provided for different periods of 1985 and 1986. While the ratio of sorghum to meat provides only .8 the protein per LS during a late dry season sale and purchase it provides twice the calories. This is important in that the demand for calories is probably much higher in the short run than is the demand for protein. Over a long period of drought and famine it may prove to be more important to provide the greater amount of protein. However, the seed of a strategy designed to avoid this situation is available. It is represented in Table 5 by the Mid Dry Season ratios of 6.2 to 1 for protein supplied by sorghum over meat and 16.5 to 1 for calories supplied by sorghum over meat.

Table 5 provides information on the purchasing power losses and gains which occur throughout the year with respect to the amount of sorghum which could be purchased from the sale on one ox. Male cattle are used in the analysis as a proxy for other livestock species and sexes. The trends in market price for other species and sexes follows that of male cattle

closely and justifies this price for use as a proxy. It is assumed that the Baggara wait to sell livestock as a drought situation reaches crisis levels which appeared to have been the case in 1985.

During the dry season 1983-1984 the weighted average of male cattle prices in the Kadugli market was 261.59 LS/AU. At that time the sale of one animal could have been used to purchase 494 kilograms of sorghum. The downward trend in prices which lasted through the end of an extended drought in July of 1985 and the the upward trend in prices for sorghum during the same period resulted in loss of purchasing power. Using average price data for the dry season of 1984-1985, the sale of one male animal could have been used to purchase only 110 kg. of sorghum. Following the drought the amount of sorghum which could have been purchased again rose to 494 kg./AU. This translates directly into Table 5 figures for protein and calorie losses and gains through the consumption of meat or sorghum. Furthermore, the same analysis would hold true if an index of meat consumption were related to an index of grain and legume consumption during the same periods.

LIVESTOCK MARKETING STRATEGIES:

The Baggara transhumant households undertake a variety of livestock marketing activities which include various strategies designed to reduce market risk. However, they appear to be subject to varying degrees of environmental risk with which they have difficulty in dealing. The major environmentally related difficulties evolve from poor grazing and limited access to water during below normal rainfall years. This results in decreased mobility on their Northern trek and reduced marketing opportunities. Reduced marketing alternatives are a result of poor transportation infrastructure which precludes overland transport of livestock by hoof to national market centers such as Kosti and Omdurman in the North. During below normal rainfall years the graze and water sources are limited and result in fewer large merchants from the North purchasing, assembling and transporting herds to the national markets.

Most livestock sales occur during the late dry season and early rainy season when the animals can be transported easily and are coming into good condition. Many of the animals will have been transported North some 150 to 300 kilometers so that costs incurred by the assembler are reduced, part of which accrues to the producer selling livestock. The amount of this differential and that which is passed on to the producer in the form of higher prices for sales undertaken is not known.

The greatest volumes of livestock sold as single animals in the Kadugli market during the period 1983 through July of 1985 occurred during the dry season months of December through February. Most sales of animals in the Kadugli market are one animal sales. Differentiating prices in sales of more than one animal or more than one animal of different species or sex was beyond the resource capabilities of the Socioeconomic section given manpower constraints and other research activities.

During the rainy season months the most volume was moved during the months of May and August (Gillard-Byers and Azrag, WSARP No. 43). The sales of animals in the Kadugli market are composed of animals reared by transhumants as well as sedentarists. Seventy three percent of the transhumants interviewed maintained that most sales undertaken by their households occurred during the period March through May yearly. This coincides with late dry season and early rainy season, a period when the transhumant households are preparing to begin the trek and also the period of rising non livestock commodity prices. It also represents a period when large merchants assembling herds for transport to national markets can transport the animals over long distances as the rains move North.

Producers were asked whether at the time of livestock sales they were doing so to purchase food, livestock or both food and livestock. Forty-five percent said they sold livestock to purchase food while 53% responded that they purchased both food and livestock. Less than 2% of the respondents said they purchased livestock with cash generated directly from the sale of another animal. This provides evidence that the purchase of food is a main goal associated with the sale of livestock. It also suggests that income from sale of livestock and labor is kept in the form of cash in order to make purchases of livestock. During periods of drought or famine this goal is likely to become the single most important goal. Meeting this goal may require considerable time and effort on behalf of members of the household.

Transhumant producers identified thirty-six markets which are located along their migratory route. These markets act as centers for the potential sale of livestock and purchases of small amounts of grain and other goods as well as for the provision of services. Seven of these markets could be considered important markets for many of the transhumants migrating along routes to the North of Demick dry season grazing areas. The seven important market towns were Dilling, El Dushol, Kerkaria, Kurgol, Kweik, Fershaia and Samasim. All of these are located to the North of Kadugli and South of El Obeid.

The data provided here suggests that most of the marketing of transhumant livestock occurs during the late dry and rainy seasons in markets to the North of their dry season grazing areas. Furthermore, most sales are undertaken to provide cash for food or food and livestock purchases. Given these findings and data provided early in the paper a scenario for marketing strategies can be outlined.

MARKETING STRATEGY SCENARIOS:

Three different strategies will be discussed here. Two of these strategies should provide the transhumant household with more residual disposable income and greater food security. At the same time they should smooth market price fluctuations and reduce meat costs at the retail level for the consumer. The third strategy represents the typical marketing activity of the transhumants. The first is the optimal strategy relative to the second and third. Strategy one entails the sale of livestock and the purchase of sorghum during February. This represents the period when the transhumants have reached their dry season grazing areas located around

Demick. Strategy two proposes the sale of livestock during February with the purchase of sorghum during the rainy season. The third strategy, that which is employed by the transhumants, entails the sale of livestock and purchase of sorghum during the late dry season and early rainy season.

Market prices for livestock, Zebu meat and sorghum are presented in Table 6. During 1985 international food aid relief tended to depress the price of sorghum in the Kadugli market. In the absence of this food aid the purchasing power from livestock sales would have decreased further. It is clear from Table 6 that a strong downward trend existed with respect to the purchasing power from livestock sales for the purchase of sorghum. Strategy number 1 in both 1984 and 1985 would have provided the transhumant household with the greatest amounts of sorghum for consumption during the rainy season and "hunger" period in July and August. Strategy number three which represents the normal sales strategy results in the poorest purchasing power figures during both years. This information is necessary to determine how the strategies outlined above bear on the quantities of crude protein and calories which are available to the household for consumption. Due to lack of meat and sorghum prices during the early months of 1984 prices for 1985 have been used as proxies. It is assumed that male cattle are sold and meat or sorghum is purchased and consumed. Meat prices at the household level from slaughter of animals have not been derived but are expected to be lower than retail prices. How then does this relate to the protein and calorie nutrient levels in the household?

Table 7 provides insight as to the effect of these different strategies on the availability of protein and calories from the sale of livestock for the purchase of sorghum. It can be seen from the table that protein and calories from the consumption of both meat and sorghum decreased. This was associated with the declining price of livestock and the increasing price of sorghum. Again strategy one, sale livestock and purchase meat or sorghum for consumption later provides the greatest quantity of both protein and calories. However, the transhumant household cannot sell livestock and purchase meat for consumption at a later date due to spoilage. The options available for the sell of livestock and the purchase of meat to avoid decreasing nutritional levels within the household are strategies two and three. Given the results described in Tables 5, 6 and 7 an estimate of the protein and calorie balance which would exist at the household level can be made.

Table 8 gives a clear representation of the protein and caloric balance which results when comparing the possible marketing options outlined previously. Table 8 tells us how many additional days of food security exist within the transhumant household on a per capita basis from undertaking the strategies outlined. The transhumant household would be better off selling livestock and purchasing sorghum during February while livestock prices are relatively high and sorghum prices low. If strategy number two were undertaken by the transhumant household with respect to meat purchases the household would be better off in terms of available crude protein. However, during periods of famine the additional days of caloric sufficiency would probably offset those days lost in terms of protein sufficiency from consumption of sorghum. An important point

represented in the table pertains to the timing of implementing a strategy. The Baggara transhumants do not know until June whether they face an abnormal rainfall year and associated price fluctuations in the livestock and non livestock commodity markets. This fact provides strong motivation for the Baggara to consider marketing strategies which differ from what they have traditionally followed. Benefits would accrue to the Baggara and other players during normal rainfall years and low rainfall years.

If benefits in terms of nutritional sufficiency, higher incomes, lower consumer prices for meat, reduced environmental risks and others would result from employing different strategies how could a research program be set up to effect the change?

PROGRAM REQUIREMENTS:

The WSARP did not and does not include an agricultural extension component and relied upon farmer managed trials and personal interaction for dissemination of research results at the farm level. The Extension Department in Kadugli, a branch of the Ministry of Agriculture, participated with the WSARP in many different ways. However, they were poorly supported in terms of basic inputs and were therefore ineffective in carrying out the extension mandate. Practically speaking, the program would have to be implemented on a small scale starting as a cooperative effort between the extension group and WSARP scientists.

Input Requirements

Staffing requirements for a program designed to educate the transhumants in fundamental marketing strategies which differed from the traditional practices would require a compliment from different groups. Collaboration among the WSARP, Extension Department and individuals from the transhumant community would be required. The target group would be the Messirriya Baggara located around Demick, Sudan. The transhumant staff would be chosen from this group due to good relationships having been developed and an obligation to provide them with results from research in which they participated.

Cooperative action on behalf of the WSARP and the extension service would be a prerequisite for an effective program. Individuals from the extension service would be seconded to the WSARP for a two year period. They would be educated in the results of previous work and trained in the analysis of data so that they could easily transfer the information to the Baggara.

The WSARP would hire Baggara transhumant women to participate in training activities focusing on nutrition and marketing of livestock. They would be used subsequently to develop linkages at the household level in target communities and subsequently carry out training activities within the household. This training would be done on site by Extension personnel. During the course of the experiment they would be required to document consumption habits within the household and identify the production and marketing management activities of the Messirriya women.

Technical staff would be provided through the WSARP. These individuals would include the senior scientists from the Socioeconomic and the Range/Livestock Sections as well as senior and junior technicians.

WSARP would provide transport, training, technical and maintenance inputs for the program to support field activities. Technical assistance from the WSARP would participate and supervise program design, implementation and evaluation of results.

Program Design and Implementation

The implementation program would cover a three year period. During year one educational activities would be undertaken with input from the WSARP, Extension and transhumant women. This educational activity would occur during the dry season when the transhumants were located at their Southern sedentary grazing areas. Training in the use of market information would be provided in the Kadugli, Sudan livestock market beginning in the early dry season and continuing through the late dry season. During the same period transhumant women would be undertaking the household consumption and marketing diagnostic survey. Producers would be queried to identify any perceived negative effects upon herd demographics. It is anticipated that any such negative effects could be minimized or avoided completely.

Explanation of market and environmental risk guarantees would be explained and household members would be questioned about the incidence of illness among members during the dry and rainy season.

Year two activities would focus program activities. In herd and in household researcher/producer managed marketing activities would be implemented. These would include the identification and documentation of the male/female management decision structure with respect to livestock sales. The first sales of cattle during February would be undertaken and the subsequent purchase of Sorghum during the same month. A follow-up survey detailing the qualitative perceptions of the transhumant household would be undertaken during March and again during August. This would be carried out for both male and female household members independently and would provide information on the probable success or failure of the program. Guarantees protecting the producer against market and environmental risk would be instituted during year two and family members would be questioned a second time about the incidence of illness among family members during the dry and rainy seasons.

Year three would consist of monitoring producer managed in herd trials to physically validate results of year two researcher/producer trials. This would consist of documenting sales of livestock which occurred during the dry season in contrast with normal practice. Transhumant women and men would be interviewed to identify the products which they had purchased with receipts from the sale. They would be asked to provide information on the nutritional status of the household and incidence of illness among family members. The latter would be qualitative measurements providing circumstantial evidence to validate previous findings. During year three, guarantees protecting the household against market price risk and environmental risk would no longer exist.

Producers would be asked during each of the three years to give detailed information on the number of individuals with whom they had discussed the experiment. During year three they would be asked to identify all individuals whom they new had implemented a similar strategy during years one, two or three. This would provide information on rates of dissemination of the marketing strategy.

In general terms, the program would be designed to educate producers. Three target groups would be identified. They would include male producers entering the Kadugli and Demick livestock markets and female producers located in the Demick area at the household level. For purposes of program implementation no more than forty households would be identified in the Demick area for participation in the program. The participating households would be guaranteed against market risk in a manner which would not affect their marketing activities. The manner in which this guarantee would be implemented would be determined by the WSARP technical staff and approved through WSARP management. Sale date of livestock and purchase date of sorghum would be determined by the WSARP technical assistance. Collection of price information in the Demick market would be undertaken weekly during the dry season and early rainy season.

Initial implementation activities would center on producers entering the regional livestock market in Kadugli for the purpose of selling livestock. The focus of the education program during this period would be on reading graphs dealing with market trends for both livestock and commodity prices. This would be accomplished through the posting of graphs in the market with an individual from extension explaining the relationships between trends. Activity of this sort would be done on a weekly basis during the late dry season.

Subsequently, after extension personnel felt comfortable with their job, the same activity would be undertaken in the periodic market of Demick, Sudan. This would be done on a weekly basis during which time technical assistance from the WSARP would be on hand to answer questions and provide any support necessary for the extension staff.

During the period spent educating the Baggara producers in Demick a second educational activity would be undertaken. This would target transhumant wives for education in nutrition and market trend analysis. They would be provided information on fluctuations in market prices for livestock and non livestock commodities using sorghum as a proxy. It would be imperative to provide them with basic nutrition information and how the purchasing power for basic nutrients decreases as livestock prices fall and other commodity prices increase.

Summary:

Research activities undertaken by the WSARP have focused on areas where adaptive research in livestock marketing has an opportunity of succeeding in both the short run and long run. Documentation of trends for livestock and non livestock commodity prices provided a basis for measuring price differentials which existed. The collection of baseline economic data at the household level provided information necessary to identify a

potentially successful marketing strategy. Price differentials provided the basis for estimating effects which different marketing strategies would have on nutritional levels maintained within households during drought and normal years. With anticipated collaborative efforts on behalf of the WSARP, Extension Department and Baggara transhumant producers, a program was outlined to design, implement and evaluate a strategy which would result in positive benefits accruing in both the short and long run.

Using household nutrition levels as a primary measurement it has been shown that a marketing strategy emphasizing the sale of livestock during the mid dry season and the subsequent purchase of non livestock food commodities during the same period will have several beneficial effects. These results would include higher nutritional levels, associated higher disposable income levels, reduced market and environmental risk, reduced meat prices for consumers, and reduced fluctuations in livestock and non livestock commodity prices. Furthermore, it was found that the strategy would be as effective during normal years as it would be during drought years.

Anticipated effects on the production system appear to be negligible for two reasons. First, the activities would occur during the mid dry season when the transhumants reside in the Southern grazing areas resulting in a potential to store grain for later consumption. Secondly, the required livestock sales during these periods would be minimal on a household basis resulting in disproportionate benefits accruing to family members.

Additional monitoring of the effects which the marketing strategy has upon herd demographics would be necessary. Follow-up on a periodic basis after completion of the program would be undertaken when technical assistance staff were in the area.

Dissemination rates would provide information on the potential impact at regional and national level for provision of economic policy options. At the household level, training in analysis of market trends and in nutrition education would provide new tools for transhumant producers to use in their best interest.

Program implementation would require collaboration between technical assistance from the MSARP, Extension Service and Baggara transhumants. The WSARP would provide logistical support and technical assistance while the Extension Department and Baggara transhumants would provide technical assistance.

The three year program would provide an adoptable technology within the reach of the Bagarra transhumants. It would result in both direct and indirect benefits in both the short and long run at the micro and macro economic levels. The potential for sustainable integration of agricultural research, agricultural research delivery systems and producers at the household level would be increased.

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Table 1: Markups on a Malwa of Sorghum in kadugli Area Villages

	Kathca	Kululu	Dobeibat	Abu Seifa	Damic
markup %	19.1	20.3	17.2	11.6	5.4
std.	15.3	9.5	6.9	0.8	1.7
n	12	16	14	3	8
range	5.0-42.9	11.1-37.5	7.5-33.3	11.1-12.5	3.4-9.1

Note: One malwa weighs approximately 2.83 kg by volume for sorghum. We distinguish markup, with the selling price as the base, from markon, where purchase price is the base. For example, a merchant who buys a malwa of sorghum for LS 3.00 and sells it for LS 4.00 has a markup of 25% but a markon of 33%. These terms are confused so often in practice that one can rarely be certain what the authors mean by the term “markup” unless the base is explicitly stated.

Source: Speece, M. WSARP Report No. 49, p. 9.

Table 2: Family Composition during Trek: Baggara Transhumant Households, 1985

Householder Members		%	n
Male:	1) Head of Household	9	32
	2) Child < 16 years	23	84
	3) Adult ≥ 16 years	11	39
	4) Cowboy	9	34
Female:	1) Spouse	11	39
	2) Child < 14 years	24	88
	3) Adult ≥	12	44

Source: Gillard-Byers, T.E. 1985 Phase II Marketing Survey

Table 3: Nominal Wage of Sorghum and Cattle meat Crude Protein and Calories, Kadugli, Sudan Market
-Pre Drought and Post Drought, 1985-1986

SEASON	LATE DRY SEASON		RAINY SEASON		LATE RAINY/EARLY DRY SEASON		MID DRY	
	March-April, 1985		June-August, 1985		September-October, 1985		January-February, 1986	
	Sorghum	Meat	Sorghum	Meat	Sorghum	Meat	Sorghum	Meat
Protein (GCP/LS)	67.8	88.5	61.6	63.0	91.8	42.4	190.6	30.8
Calories (cal./LS)	2302	1125	2091	801	3118	540	6472	391

Source: Gillard-Byers and Azrag, WSARP reports no. 42 and 43.

Table 4: Nominal Wage Price of Sorghum and Cattle Meat Protein and Calories, Kadugli, Sudan Market, 1985-1986

	LATE DRY SEASON		RAINY SEASON		LATE RAINY/ EARLY DRY SEASON		MID DRY SEASON	
	(LS/kg Sorghum : LS/kg Meat)				(LS/kg Sorghum : LS/kg Meat)			
Protein	0.8 : 1		1 : 1		2.2 : 1		6.2 : 1	
Calories	2.0 : 1		2.6 : 1		5.8 : 1		16.5 : 1	
	Sorghum	Meat	Sorghum	Meat	Sorghum	Meat	Sorghum	Meat
Mean Retail Price (LS/kg)	1.49	2.00	1.64	2.81	1.10	4.17	.53	5.75

Source: Gillard-Byers and Azrag, WSARP Reports No. 42 and 43

Table 5: Purchasing Power Loses and Gains Associated With Fluctuations in the Market Price for Male Cattle and Sorghum, Kadugli, Sudan Market, 1983-1986

	Sorghum		Male Cattle		Kilograms of Sorghum Purchased From Livestock Sale
	(LS/Malwa)[1]	(LS/Kg)	(LS/AU)	(Weighted LS/AU)	(Kg)
Dry Season – 1983-1984	1.50[2]	.53[2]	259.86	261.59	494
Rainy Season – 1984	3.77	1.33	211.43	223.80	168
Dry Season – 1984 – 1985	3.80	1.34	152.41	148.28	110
Rainy Season – 1985	4.51	1.59	168.61	173.73	109
Mid-Dry Season - 1986	1.50	.53	259.86[3]	261.59[3]	494

[1]One malwa averages 2.83 kg. A Malwa is a volume of measurement. Grain weight will vary between 2.6 and 3.0 kg/malwa for sorghum.

[2]Mid-dry Season prices are used due to no available data.

[3]Dry Season Prices for 1983 are used due to no available data.

Source: Gillard-Byers and Azrag, WSARP Reports No. 42 and 43.

Table 6: Market Prices for Livestock, Zebu meat and sorghum Under Three Marketing strategies, Kadugli, Sudan Market, 1984 and 1985

	Male Cattle[1] (LS/AU)		Zebu Meat[2] (LS/Kg)	Sorghum[2] (LS/Kg)
Strategy No.:				
1984: Month		1984: Month		
1. February	258.51	February	2.00[3]	.39[4]
2. February	258.51	June	2.50[3]	1.33[5]
3. June	210.17	June	2.50[3]	1.33[5]
1985: Month		1985: Month		
1. February	158.01	February	2.00	1.50
2. February	158.01	June	2.50	1.66
3. June	136.41	June	2.50	1.66

[1]Source: Gillard-Byers and Azrag, WSARP Reports #43 and 55 (LPIDB).

[2]Source: Gillard-Byers and Azrag, WSARP Reports #42 and 55 (CPIDB).

[3]1985 Prices – Price information had not been collected prior to September, 1984.

[4]February 1986 market prices used. Price information had not been collected prior to September 1984.

[5]September 1984 prices.

Table 7: Total Crude Protein and Calories Available Under Three Marketing Strategy Scenarios
Kadulgi, Sudan Market, 1984 and 1985

Sale: Livestock	Purchase: Meat		Purchase: Sorghum	
Purchase: Meat or Purchase: Sorghum	Consume: Meat[1]		Consume: Sorghum[2]	
Sale Month-Purchase Month	Crude Protein (,000 grams)	Calories (,000 kcal)	Crude Protein (,000 grams)	Calories (,000 kcal)
1984:				
1. February-February	----	----	66.9	227.4
2. February-June	18.3	18.9	19.6	66.7
3. June-June	14.9	18.9	16.0	54.2
1985:				
1. February-February	----	----	10.6	36.1
2. February-June	11.2	14.2	9.6	32.6
3. June-June	9.7	12.3	8.3	28.2

[1]Grams of crude protein/100 grams of zebu meat = 17.7
Calories/100 grams of zebu meat = 22.5

[2]Grams of crude protein/100 grams of sorghum = 10.1
Calories/100 grams of sorghum = 343

Sources: 1) FAO. 1970.
2) Schmitt. 1979.

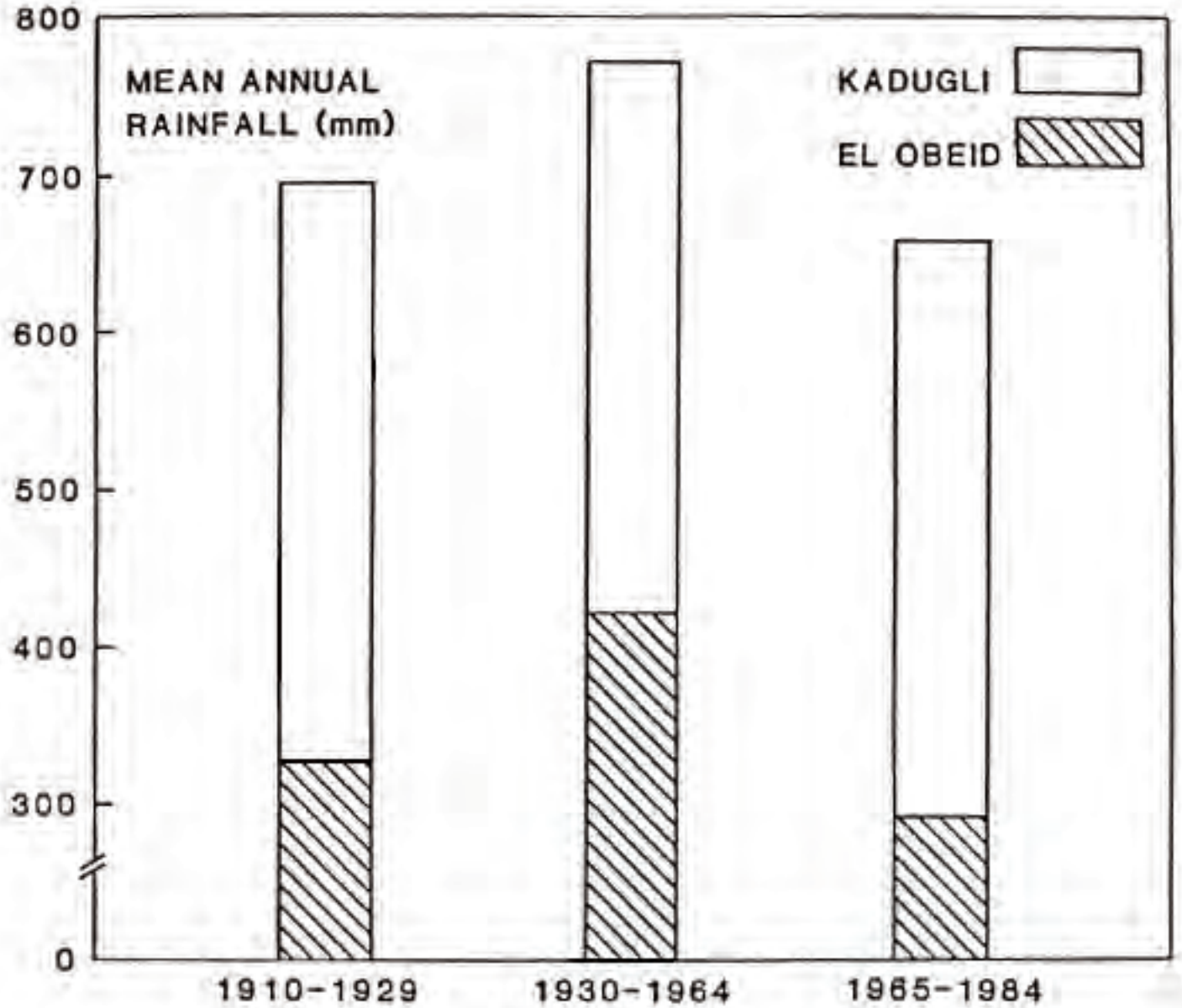
Table 8: Protein and Calorie Balance Employing strategy One for Purchase/Consumption of Sorghum Versus Strategies Two and Three for Purchase/Consumption of Meat

	Crude Protein (,000 grams)	Calories (,000 kcal)	Crude Protein (Days[1])	Calories (Days[1])
Sell: Livestock Purchase: Meat				
1984: Months				
Feb. – Feb.	--	--	--	--
Feb. – June	48.6	204.1	675	88
June – June	52.0	208.5	722	89
1985: Months				
Feb. – Feb.	--	--	--	--
Feb. – June	-0.6	21.9	-8	9
Feb. – June	0.9	23.8	13	10

[1]Calcualted using target figures for daily/capita crude protein and calorie requirements. Source: Third World Food Survey, FAO, PP. 96 and 97.

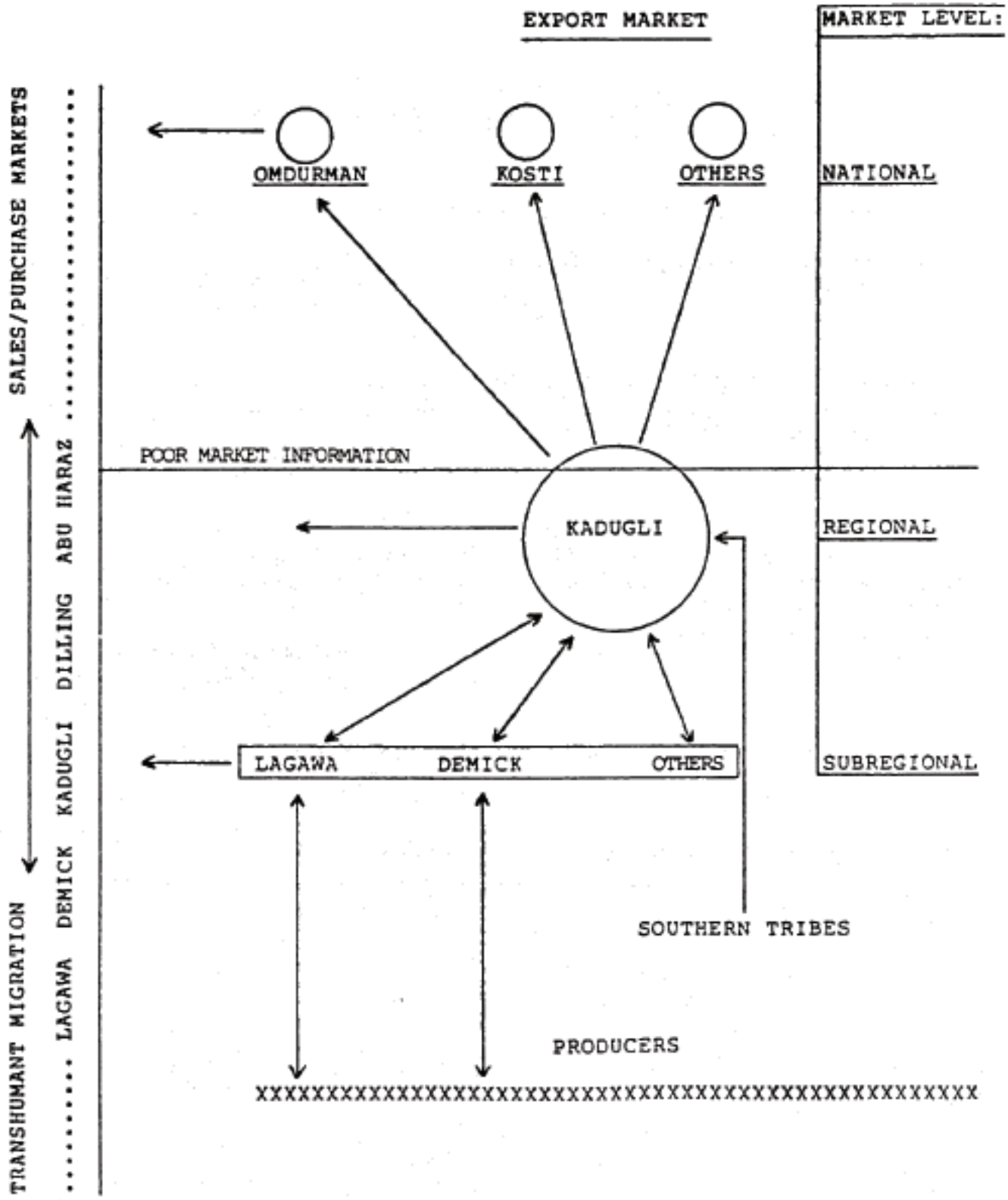
FIGURE 1: MAP OF SUDAN AND SURROUNDING AREAS

FIGURE 2: MEAN ANNUAL RAINFALL FOR SELECTED PERIOD AT KADUGLI AND EL OBEID, SOUTH AND NORTH KORDOFAN, SUDAN



Source: Riley, J., WSARP No. 38.

FIGURE 3: SPATIAL MARKET STRUCTURE



Source: Gillard-Byers, Washington State University Seminar Series.

FIGURE 4: MAXIMUM PROFIT MARGINS OF CHANNEL PARTICIPANTS IN SORGHUM MARKETING

Katcha Producer Price Dec LS 2/Malwa (M)

Shopkeeper buys $ LS 2/M in Dec Katcha
  sacking costs - .0l/M maximum profit margin
  10.7 - 19.6X

Shopkeeper sells $ LS 2.25 - 2.50 in Dec in Katcha
Transport merchant buys @ LS 2.25 - 2.50 in Dec in Katcha
  transport cost - .025/M
  maximum profit margin
  2.4 - 18.8X

Transport merchant sells @ LS 2.50 - 2.80 in Dec in Kadugli
Kadugli wholesaler buys $ LS 2.60 - 2.80 in Dec in Kadugli
  average losses $ 15X
  inflation $ 202 (40X/year)
  storage cost .01/M maximum profit margin
  4.8 - 10.6X

Kadugli wholesaler sells @ 4.20 - 4.60 in May in Kadugli

Source: Speece, M., WSARP Report No. 49, page 21.

Table 2

PERCENT CHILDREN RECEIVING SPECIFIC FOODS
BY FOOD CROUP: TOTAL SAMPLE

Food Group	February	March	April	May	Average
Dairy	82	68	64	72	71
Veg/Fruit	76	58	57	38	57
Grain	98	98	93	92	95
Meat	38	48	47	44	44
Sample Size (n=)	50	50	58	50	

Table 3

CHILDREN REVEIVING SPECIFIC FOOD CROUPS
AVERAGE PERCENT (2-5/86)

Food Group	Breastfed	Not Breastfed	Total
Grain	84	100	95
Dairy	90	63	71
Veg/Fruit	51	60	57
Meat	25	52	44
Sample Size (Mean)	15	37	52

FIGURE 7:

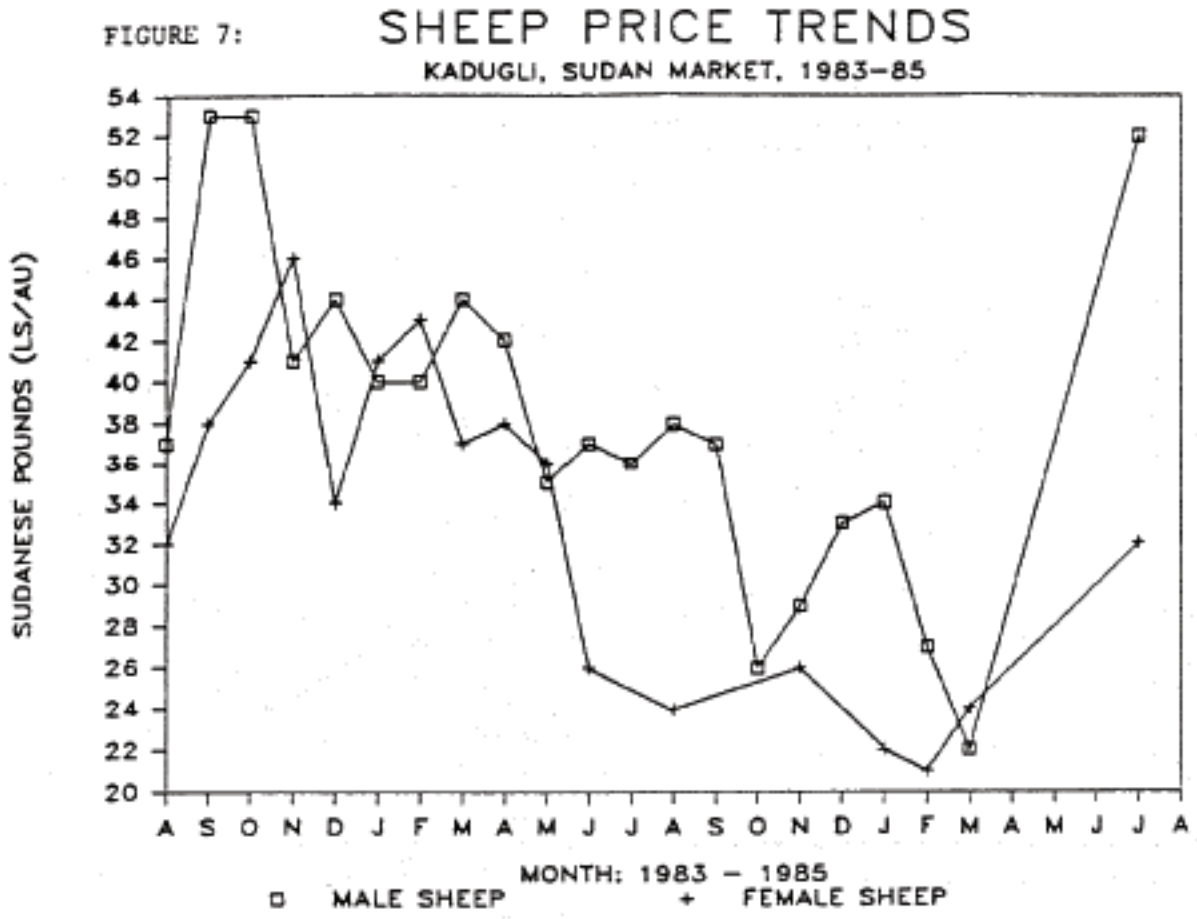


FIGURE 8:

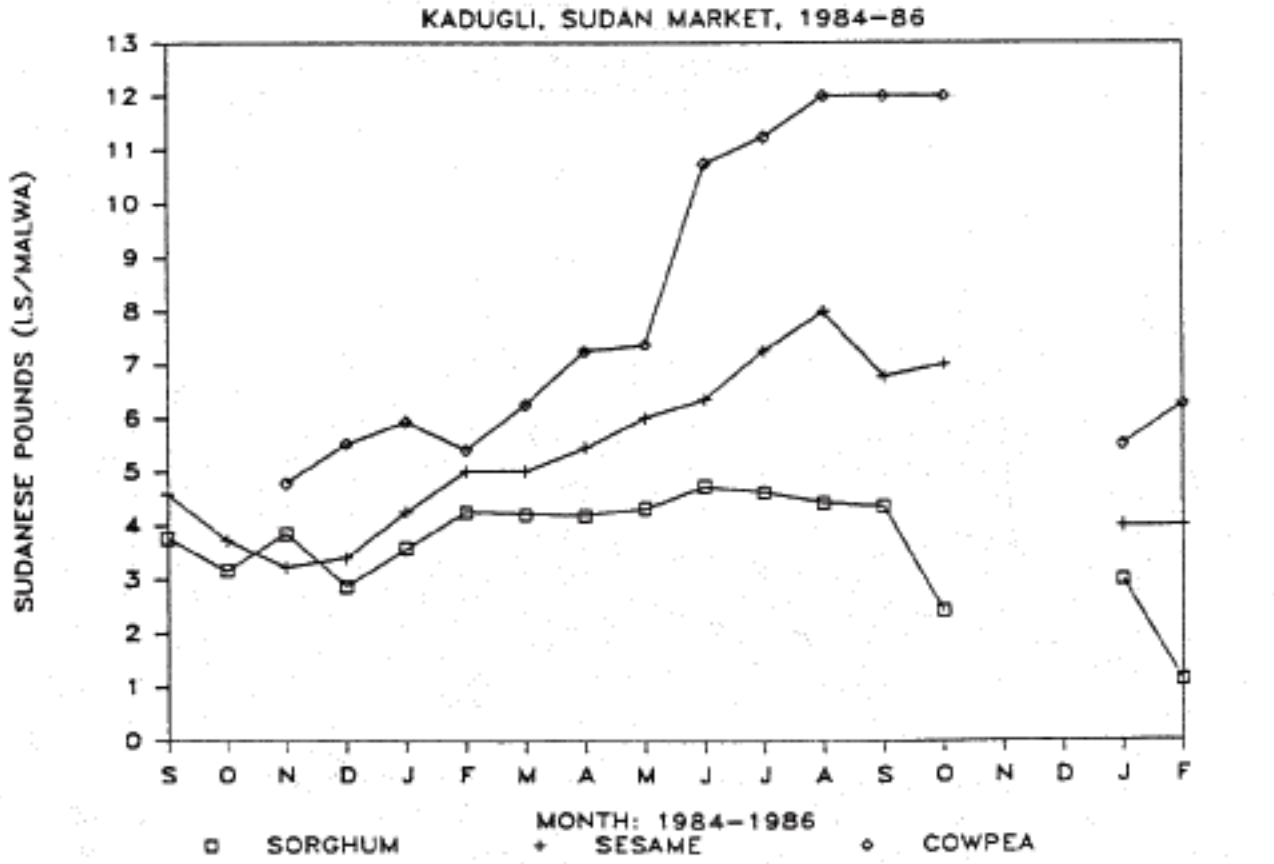


FIGURE 9:

WHOLESALE PRICE FOR SORGHUM, SESAME

COWPEAS-KADUGLI, SUDAN MKT. 1984-86

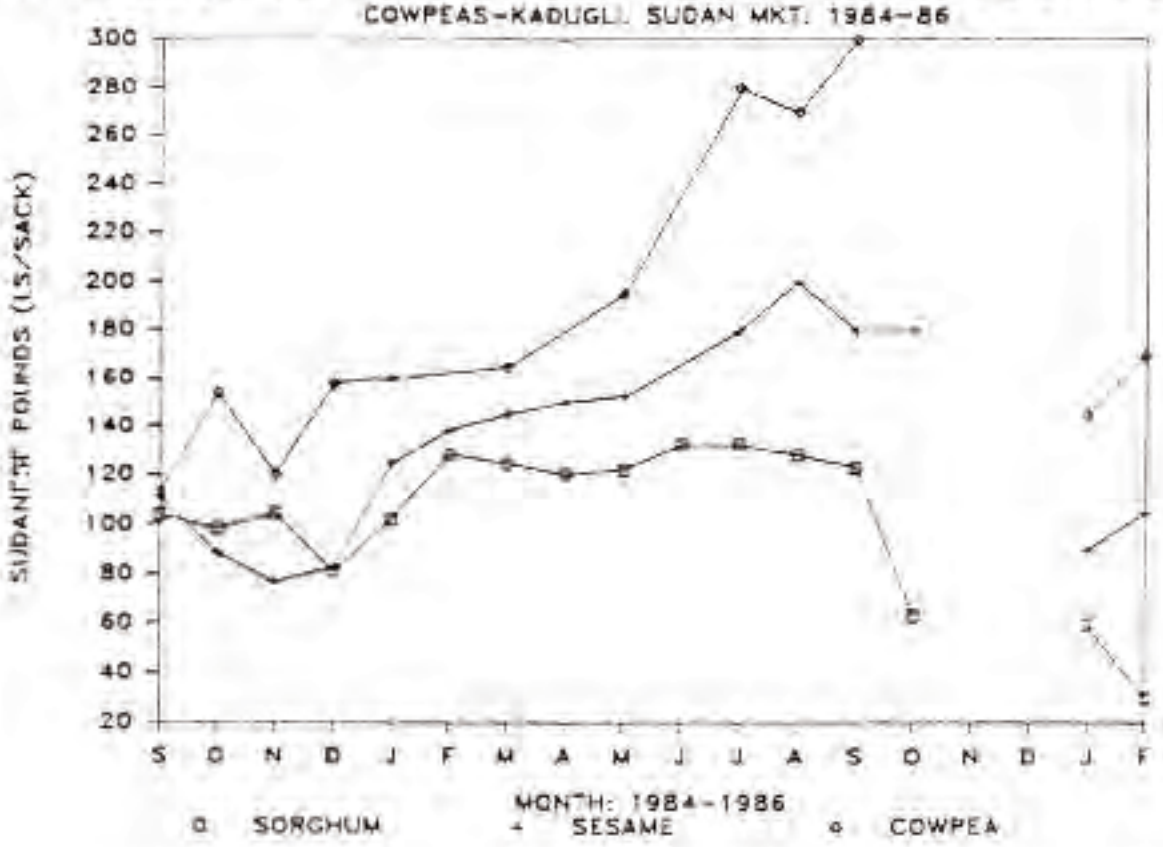
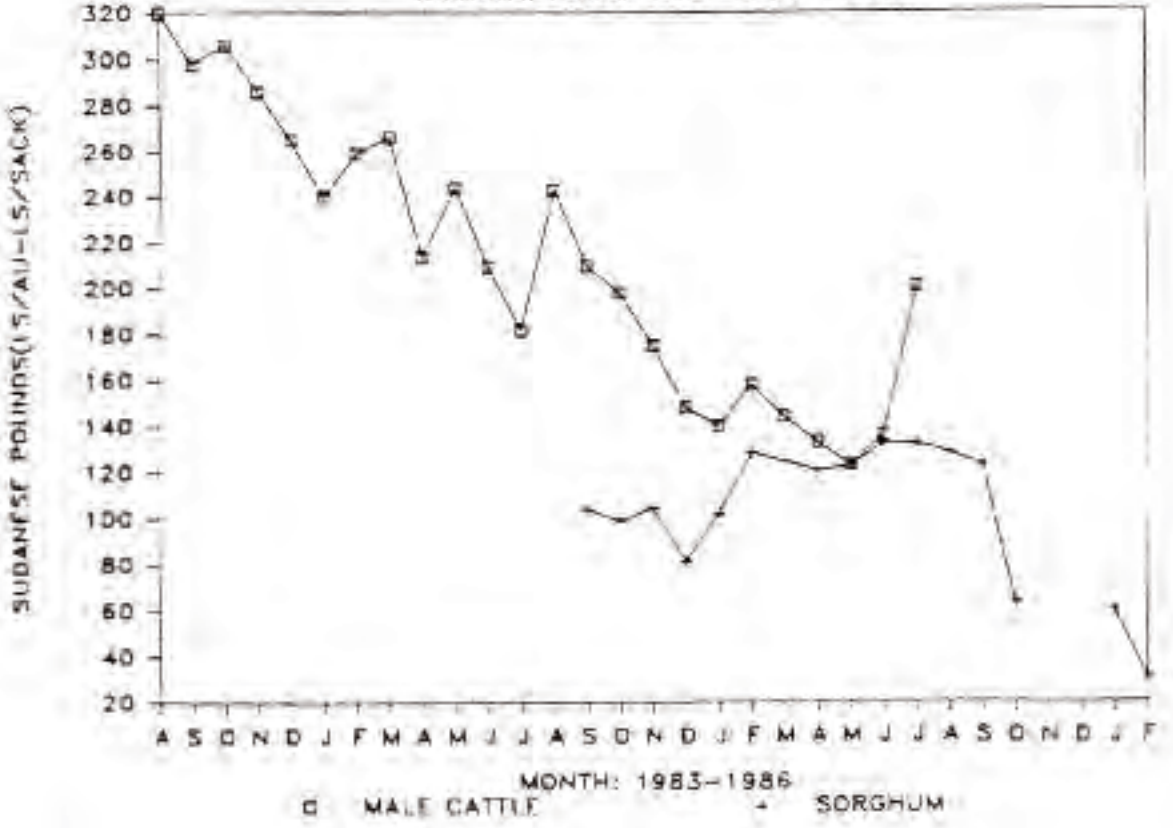


FIGURE 10:

MALE CATTLE AND SORGHUM UNIT PRICES

KADUGLI, SUDAN MKT. 1983-1986



Nutritional Consequences to On-Farm Research in Swaziland

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Introduction

During the past five years, food policy economists, the FAO, and farming systems theorists have all become increasingly interested in the inclusion of nutrition and food consumption concerns in the design and execution of agricultural development projects. This interest stems from the recognition that diet and nutritional status are basic indicators of the well-being of rural families. Dietary information is also critical to the process of food policy planning. In addition, it is increasingly recognized that the process of agricultural production is linked to food consumption in rural households.

Awareness of these concerns has led the Swaziland Cropping Systems Research and Extension Training Project (SCSRETP) to add a food consumption/nutrition component to its ongoing program of socio-economic research. While this component is designed to address a number of production and consumption issues, its primary focus is on the dietary consequences of changing farming practices. This paper discusses the rationale behind the introduction of food consumption research into farming systems in Swaziland. It then reviews some of the preliminary results of that research. Finally, it offers suggestions for application of the information derived from this study.

Nutrition as an Agricultural Problem

Research on the relationship between nutrition and agriculture has looked at both the impact of consumption on production and the impact of production on consumption. In general, studies of the former issue have been biological in focus, and studies of the latter economic. This has resulted in a literature on malnutrition and work performance which is seldom seen by policy economists, and a literature on food policy which is often foreign to nutritionists. The recent attempts to integrate these two aspects of what is minimally a complex problem are therefore long overdue. Because nutritional well-being is the result of both biological and social forces, long-term development depends on consideration of both.

While there is still some disagreement as to the magnitude of its impact, there is general agreement that malnutrition is detrimental to work performance (Latham 1974). The classic studies of Keys, et.al. (1950) showed that healthy young men undergoing voluntary partial starvation lost work capacity as they lost weight. Similarly, work by Viteri (1971, 1974) on Guatemalan peasants indicated that lowered work capacity was related to poor nutritional status. Both caloric deficit and iron-deficiency anemia were related to low productivity

and shortened working hours in agricultural labor, while nutritional supplements improved performance. Similar results have been found for anemic rubber workers in Indonesia and for underweight Jamaican cane cutters (Latham 1974).

While adequate diet can increase the stamina of agricultural laborers, the economic impact of this improved working capacity remains uncertain. A large proportion of the undernourished labor force in the developing world is not employed for wages, and thus it is difficult to translate their performance into economic terms. In the case of women and subsistence farmers (not mutually exclusive categories), lower energy levels may simply be translated into longer hours of work or the delegation of tasks to children (Arteaga 1974). By contrast, the impact of poverty on nutritional status is well documented, and need not be reviewed here.

Recent integrated treatments of nutrition and agricultural development have stressed the dynamic interaction of biological and social factors influencing both nutritional status and agricultural production. Pinstrup-Andersen, for example, has indicated that agricultural production research influences human nutrition through its effects on the following factors:

1. Incomes acquired by households at risk of having malnourished or undernourished members;
2. The prices they must pay for food commodities;
3. The nature of the production system among semi-subsistence farmers;
4. Risk and fluctuations in food production, storage, prices, and incomes;
5. The nutrient composition of the foods available to malnourished households;
6. The composition of household income and budget control, and the allocation of women's time;
7. The demand for labor;
8. Expenditure of human energy;
9. Infectious disease.

(Pinstrup-Andersen 1984:14-5)

Changes in food supply, he concludes, affect nutritional status only to the extent that the food consumption of malnourished or at-risk individuals is affected. Thus the relationship between agricultural production and nutritional status of producers is mediated through the dynamics of the consumption system in the unit of production.

In a recent review of the work on nutrition and agriculture for Africa, Eicher and Baker (1982) have noted that the majority of the research conducted

in this area centers on three major problems. These are 1) seasonal hunger, 2) the impact of cash cropping on nutritional status, and 3) strategies for alleviating malnutrition (Eicher and Baker 1982:212-15). "Seasonal hunger" is the term used to describe the seasonal shortfall in both staple and non-staple crops described for many African societies. While patterns of seasonality vary for different ecological situations, shortfalls are most obvious in the preharvest period. Because this is often a period of peak labor demand and increased energy expenditure, the nutritional effects are heightened. If low caloric intake at this time results in lowered working capacity, agricultural production may also be affected.

While agricultural policy in many African countries emphasizes the increased production of cash crops, some researchers have suggested that commercial crop production may have adverse nutritional effects (Fleuret and Fleuret 1980). Huss-Ashmore and Johnston (1985), for example, note that commercial agriculture may interfere with nutritional status by at least four routes:

1. It may interfere with consumption patterns in the household through reallocation of food reserves to commercially employed laborers.

2. It may interfere with either quantity or quality of food supply, through reduction of food production. Many authors have noted that crop diversity declines with a shift to cash cropping, and that foods no longer planted are replaced with commercial foods of inferior nutrient content.

3. It may interfere with both subsistence production and domestic processes of reproduction, through reallocation of household labor. This process may increase the demands on labor time of women, thus changing cooking habits. The seasonality of these demands can lead to seasonal problems in nutrition and health for rural women and their children.

4. In addition, commercial agriculture may interfere with household acquisition of food by changing control of income, budgeting, and resource distribution from females to males within the household (Huss-Ashmore and Johnston 1985:497-8). Although Eicher and Baker (1982) conclude that the cash-crop hypothesis has yet to be rigorously tested, research currently underway in Africa should resolve some of the controversy.

While strategies for alleviating malnutrition have traditionally been considered health interventions, African governments have begun to recognize that this is a multi-sectoral problem. Efforts continue to increase the protein content of weaning diets and to establish nutrition clinics. However, ministries of agriculture have also seen the need to increase efforts at nutrition education, largely through the medium of home economics extension. There is now a need to coordinate these efforts with those of health personnel, as well as a need to incorporate their concerns into food policy planning. Eicher and Baker (1982) see increased recognition that problems of malnutrition can only be solved by including poverty and malnutrition elimination as goals in

agricultural policy, planning, and research. Research linking food consumption with farming practices of poor rural families in Swaziland is a preliminary step in that process.

The relationship between food consumption and agricultural production has been characterized by Frankenberger (1985) as a set of six linkages. These are:

1. seasonality of production, which includes seasonal Patterns of food availability, malnutrition, human energy expenditure, and terms of trade for the poor;

2. crop mix and minor crops, including production of Subsistence vs. cash or non-food crops;

3. income—regularity, kind, and recipients;

4. the role of women in production;

5. crop labor requirements; and

6. market prices and their seasonality.

(Frankenberger 1985:8-9)

Research by the Swaziland Cropping Systems Project (SCSRETP) suggests that many of these linkages have relevance for the Swazi case. Future interventions in the farming system must therefore take account of consumption practices. The preliminary findings of the food consumption study reported below point to several areas where improved farming practices may affect dietary patterns of the rural Swazi homestead.

Nutritional Problems and the SCSRETP

While Swaziland does not have nutritional problems of the magnitude reported for other African countries there are nonetheless indications that the nutritional environment could be improved. For example, the recent National Nutrition Survey indicated that 30% of preschool children in rural areas were stunted (National Nutrition Council 1986). In addition, rural clinics have reported unacceptable levels of protein-energy malnutrition. Stunting was most prevalent among children 18 to 24 months of age, and among rural families on Swazi Nation Land (communal tenure land). Lack of a cash income also appeared to be associated with nutritional problems. While much of this stunting was thought to be related to diarrheal disease, consumption patterns were also implicated. Young children were less likely than the rest of the family to receive starches other than maize, and were also less likely to receive oil, margarine, or other calorically dense foods. Dietary variety was low, with some children receiving little more than dilute maize gruels. Dietary variety for the rest of the family was also low, with legumes and groundnuts eaten by less than 10% of households surveyed (National Nutrition Council 1986:16).

Cappetta (1983) confirms the impression of suboptimal food consumption patterns for many Swazi households. In her survey, 60% of households showed

inadequate caloric intake, and 20% were deficient in protein. Intake of fats was very low overall, comprising less than half the recommended proportion of calories. Calcium, riboflavin, niacin, and vitamin A presented a problem for 50% to 90% of households. All of these deficiencies were exacerbated seasonally.

These studies give the impression of a rural Swazi diet which is either regularly or seasonally lacking in calories and variety, particularly for low-income households. Interested in possible production solutions for these problems, the Cropping Systems Project has initiated a program of food consumption research. Preliminary informal interviews by the nutritional consultant indicated that most homesteads associated with the Project either produce or can buy sufficient maize to satisfy their staple requirements. However, these interviews also confirmed that there is a seasonal shortage of many foods, particularly legumes and vegetables. The end of the winter dry season was thought to be particularly difficult, in that legumes were in short supply, and milk, eggs, and wild greens were essentially absent. In some households, the shortage of ingredients for the traditional side-dish or "relish" also limited the amount of staple maize porridge that was cooked.

Based on these preliminary interviews, it was decided that a more detailed food consumption study should be undertaken to quantify the extent of nutritional gaps for homesteads cooperating with the SCSRETP and to suggest foods which might be economically produced to fill those gaps. These efforts would concentrate on maintaining or increasing the diversity of crop mix for 'rural homesteads. As Frankenberger (1985) has noted, the production of minor crops can have a significant effect on consumption patterns. Cash crops in particular tend to reduce the overall diversity of crop mix, despite their potential to increase rural incomes.

Recognition of this linkage led the Cropping Systems research team to identify two sets of specific nutritional concerns which they needed to address. These were 1) the nutrition and consumption effects of the switch from subsistence farming to cash crop production (particularly cotton and tobacco), and 2) the dietary effects of specific on-farm research trials. Trials thought most likely to have dietary effects were those concerned with legume and other vegetable production, hybrid maize production, and the use of herbicides. Legume trials were thought important for their potential for increasing protein supplies for nutritionally marginal households. The introduction of soybeans, which are highly productive under Swazi conditions, is of particular interest as a potential dietary supplement.

The use of herbicides by small farmers in Swaziland also has a potentially large dietary impact. The traditional Swazi farming system relies heavily on the intercropping of vegetables with maize to insure dietary variety. Beans, pumpkins, gourds, and melons are the domestic crops most commonly grown. While whole-field herbicide application could eliminate the mid-summer weeding bottleneck and improve maize yields (particularly for hybrid maize), it may also interfere with intercropping. In addition, it would eliminate the supply of edible wild greens which are a seasonal staple of the Swazi diet.

Previous research has indicated that wild foods are nutritionally important in Swaziland (Ogle and Grivetti 1985 a,b,c,d). Knowledge of wild food species continues to be handed down to children, such that they have

almost as much recognition of edible species as older, more traditional, generations. Probably the most important contribution to diet is made by opportunistic plant species which invade areas disturbed by human activity. These "edible weeds of agriculture" are not only harvested as foodstuffs during weeding, but are sometimes actively cultivated or protected (Ogle and Grivetti 1985c). The discovery that weeds are actually intercropped in Swazi fields has led the Cropping Systems Project to begin a search for nutritionally appropriate herbicide recommendations. Further consumption- production interactions are currently being explored through a food consumption survey.

Survey Methodology

Households chosen to participate in the food consumption study were chosen randomly from all potential cooperator homesteads with whom the Socio-economic Section of the Project had conducted informal socio-demographic and agronomic interviews during the 1985-86 cropping season. Twelve homesteads were chosen from each of the ten Rural Development Areas in which the SCSRETP is working, for a total of 120 target homesteads. All four of the agro-ecological zones of the country were represented in the sample. The sample also included subsistence, commercial, and semi-commercial farmers.

Data collection began in February, 1986, and will continue through March, 1987. This is a complete consumption cycle, from just before one harvest through the beginning of the next. Research assistants employed by the Ministry of Agriculture and cooperatives have been instructed to visit each homestead once a month to collect food consumption and cash expenditure data. Dietary data are collected through the use of a 24-hour recall interview with the woman in charge of the kitchen in each household. She is asked to recall all food prepared for her household during the previous day, as well as everything eaten by her and by her preschool child during that period. To facilitate recall, she is asked about her activities at five different periods of the previous day. These activity patterns will be used to estimate energy requirements and to analyze approximate nutrient requirements. Interviews are rotated through the week to capture weekend as well as weekday consumption patterns. In addition, anthropometric measurements of all women and preschool children in the sample were collected during June, 1986, to determine nutritional status.

Data collected by the research assistants are coded and prepared for analysis by the Socio-economic Section of the Project. At present, preliminary results are available only for the first four months of data collection, from February through May, 1986. Even so, nutritional gaps and seasonal trends in consumption can be identified. The food group analysis summarized below indicates the validity of project concerns with crop and food variety.

Preliminary Results

The following preliminary analysis of food consumption is based on the analysis of food groups in the diet. Most educated people, both in Swaziland and the United States, are familiar with food groups as a tool for nutrition education. When asked by the nutrition consultant, team members from both

Table 1.

List of Food Groups

Food Group	Nutritional Description	Examples
1. Dairy	High in CHO & Protein; Fat Variable; Supplies Ca & P	Milk, Emasi, Yogurt, Infant Formulas
2. Vegetables	Small Amounts CHO & Protein; Significant Vitamins & Minerals	Spinach, Onion, Ligusha, Tomato, Umbhidvo, Beetroot
3. Fruits	Moderate CHO; Negligible Protein & Fat; Vit. A & C	Guava, Banana, Papaya, Apple
4. Grains	High in CHO, especially Starch; Small but Significant Protein	Maize, Rice, Bread, Sweet Potato, Pumpkin
5. Meats	Significant Amounts of Protein; Low in CHO; Fat Variable	Meat, Eggs, Fish, Legumes (Incl. Beans & Groundnuts)
6. Oils	High fat, Negligible CHO & Protein	Vegetable Oil, Butter, Mayonnaise, Coconut
7. Low or No Cal	Negligible CHO, Protein, Oil	Coffee, Tea, Spices
8. Sweets/Alcohol	High in CHO and virtually nothing else	Sugar, Candy, Soft Drinks, Cookies, Spirits
9. Prepared & Misc.		Nik-Naks, Soup Mixes

countries could remember having learned about food groups in school, even if they could not currently recall all of them. For this analysis, foods consumed were classified into four major food groups--grains and starches, vegetables and fruits, meats and legumes, and dairy items. Other minor items such as sweets and alcohol, or snacks and prepared foods were included in parts of the analysis, table 1 gives a complete list of food groups used.

While quantities of food consumed have not yet been analyzed, it is possible to get a picture of dietary complexity from looking at the frequency with which different types of foods are used. Because humans are adapted to a highly varied diet, a greater diversity of foods gives them a better chance of receiving all necessary nutrients. This analysis therefore approached the idea of food frequency in two ways. First, it looked at the frequency of use of each food group as a percentage of all food items reported. Second, it looked at the proportion of people in the sample using or not using each food group each month.

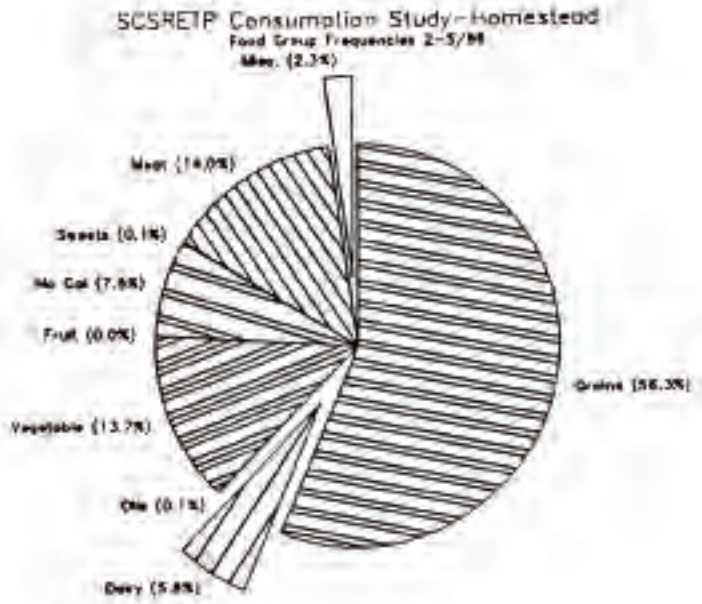
Figure 1 shows the relative frequencies of all nine food groups prepared by homesteads and eaten by women and children for the entire period of February through May. That is, it gives the proportion of all food items listed as being used during the day which were provided by a particular food group. Thus the food group "grains" accounts for 56% of all food items prepared by homesteads during this time, and approximately 49% of all individual food items consumed by women and children. Note that these figures do not take into account amounts of food eaten, merely the frequency with which they were reported during the four-month period. It is likely that when weights and volumes of food used are taken into account, grains and starchy vegetables will account for an even larger percentage of the diet.

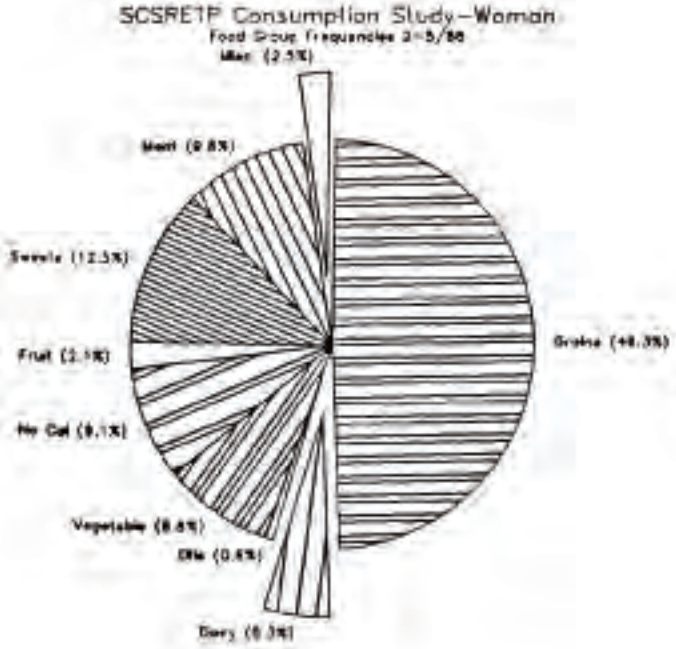
In contrast to the constant high proportion of the diet supplied by grains and starches, the frequency of dairy products varies widely by consumption unit. Homesteads report that approximately 6% of food items prepared fall into the dairy category (including fresh and soured milk). Similarly, women report dairy products as comprising about 5% of the diet. Children, on the other hand, consume dairy products much more frequently, accounting for 21% of all items consumed. Vegetables (primarily wild and domesticated greens) make up almost 14% of the food items prepared by households. Both women and children report them as accounting for 9% of food items eaten. They are much more important as sources of vitamins than fruits, which constitute only 2-3% of diet items. Note that fruits are not listed for the household as a whole, because they are generally eaten raw as snacks, and therefore are not listed among items prepared.

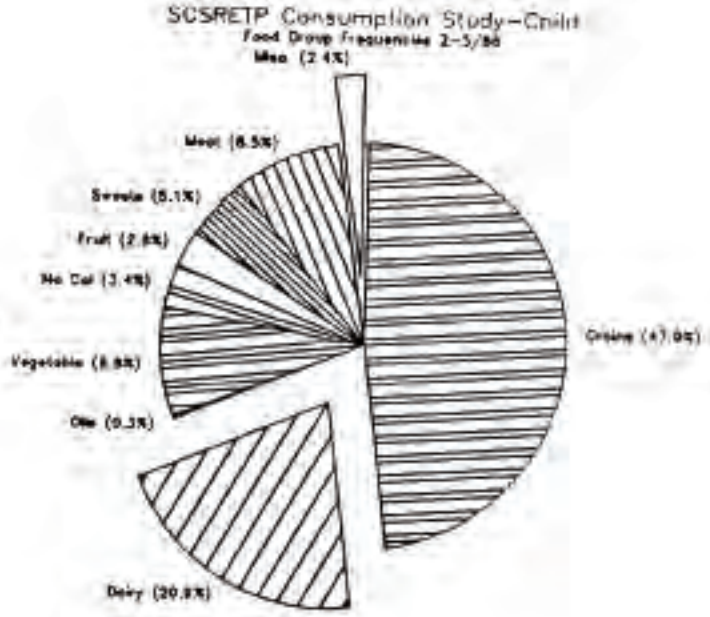
Meat as a proportion of foods used also varies by the unit of observation. As with vegetables, meat accounts for 14% of foods prepared. However, it accounts for only 8-10% of foods eaten by women and children. Part of this discrepancy comes from the difference in proportion of foods prepared vs. those eaten, as in the case of fruits. However, meat is sometimes cooked and eaten just by men, so that they do in fact consume it more often than women and children.

The diets of women are notable for the frequency with which foods from minor food groups are eaten. The frequency of "no cal" foods and sweets is

Figure 1.


SCSRETP Consumption Study-Homestead
Food Group Frequencies 2-5/88
Misc. (2.3%)
Meat (14.0%)
Sweets (0.1%)
No Cal (7.6%)
Fruit (0.0%)
Grains (56.3%)
Vegetable (13.7%)
Oils (0.1%)
Dairy (5.8%)


SCSRETP Consumption Study-Woman
Food Group Frequencies 2-5/88
Misc. (2.5%)
Meat (9.8%)
Sweets (12.5%)
Grains (48.3%)
Fruit (2.1%)
No Cal (9.1%)
Vegetable (8.6%)
Oils (0.6%)
Dairy (9.3%)


SCSRETP Consumption Study-Child
Food Group Frequencies 2-5/88
Misc. (2.4%)
Meat (6.5%)
Sweets (5.1%)
Fruit (2.8%)
No Cal (3.4%)
Grains (47.0%)
Vegetable (8.8%)
Oils (0.3%)
Dairy (20.8%)

particularly interesting. "No cal" foods (primarily tea) represent 9% of those reported for women, and sweets represent 12.5%. Most of the sugar reported is in the form of granulated white or brown sugar mixed with tea or sour thin porridge. Some women report very high sugar consumption, often four to six standard teaspoons per cup of tea. Children receive much less sugar, both mixed with foods or as candy. Since both sugar and grains supply mainly carbohydrates, it is clear that these are the major energy sources in women's diets. Added together, sweets and grains account for 62% of food items reported by women.

In addition to the variation seen among homesteads, women and children, there is also some variation in relative frequency of food groups by month. While the frequency of grains remains quite stable from February through Way, there is some fluctuation in other groups. The frequency of dairy products in particular declines from almost 9% in February to 4.5% in May. The frequency of vegetables also declines during the period, from over 14% in February to 12.5% in May. These trends may reflect a real decline in the availability of specific foods. Cows give progressively less milk during the late summer and early autumn, and the number and quality of fruits and wild greens also declines. At the same time, there is an increase in the availability of starchy vegetables such as sweet potatoes and pumpkins. The frequency of meat and legume preparation increases during this period, partly due to the increased availability of beans and peas. The harvest of chickens hatched in the spring may also account for part of this trend.

The general trends shown for food preparation by the homestead are also present in the pattern of foods consumed by women. Dairy products decline from 6.4% of all food items in February to 4% in May. Vegetable use declines slightly, from 9% to 8%, while meat and legumes increase substantially, from 7% to over 12% by the end of this period. By contrast, there is no clear trend to the fluctuation in children's diets. This may mean that there is some attempt by mothers to keep the diets of children constant, even when some kinds of food are in short supply for the rest of the family.

The relative frequency of food groups in the diet gives a rough measure of dietary complexity for this sample. However, it does not indicate how this complexity or lack thereof is distributed within the population. Some individuals may consume a large variety of foods, while others may rely on only one or two food groups. In order to assess the distribution of foods within the sample, it was necessary to look at the percent of people interviewed using particular food groups.

Table 2 lists the percent of children receiving each of the four major food groups (dairy, vegetables and fruits, meat and legumes, grains and starches) for each month. On the average, 71% of children in the total sample received dairy products during the period February through May. Fifty-seven percent received either vegetables or fruits, and 95% received grains (mostly maize) or other starches (sweet potato, pumpkin). For the four-month period, only 44% of children received meat or legumes.

The only clear trend over time for the sample of children is seen in the percentage of children receiving vegetables and fruits. In February, 76% of children received fruits or vegetables, while in March this dropped to 58%. In April, this figure dropped to 57%, but in May it reached 38%. Thus only half as

Table 2

PERCENT CHILDREN RECEIVING SPECIFIC FOODS
BY FOOD CROUP: TOTAL SAMPLE

Food Group	February	March	April	May	Average
Dairy	82	68	64	72	71
Veg/Fruit	76	58	57	38	57
Grain	98	98	93	92	95
Meat	38	48	47	44	44
Sample Size (n=)	50	50	58	50	

Table 3

CHILDREN REVEIVING SPECIFIC FOOD CROUPS
AVERAGE PERCENT (2-5/86)

Food Group	Breastfed	Not Breastfed	Total
Grain	84	100	95
Dairy	90	63	71
Veg/Fruit	51	60	57
Meat	25	52	44
Sample Size (Mean)	15	37	52

many children were receiving fruits and vegetables at the end of this period as at the beginning. This reinforces the decline seen in frequency of fruits and vegetables during this time.

While ages of children in the sample have not yet been analyzed, it is possible to break the total sample of children down into those that are and those that are not being breastfed at the time of the interview. Although we are not sure, we can suggest that most of the children not currently breastfed may have been at one time, and therefore represent an older group of children. Conversely, those currently breastfed may represent a younger group who have not yet been weaned. Table 3 shows the percentage of children both breastfed and not breastfed who also are given other foods. On the average, 90% of breastfed children also receive other dairy products. Fifty-one percent receive vegetables or fruits, and 84% receive grains or other starches. Only 25% of the breastfed subsample receives meat or legumes, which would be expected if this is indeed a younger group of children.

Of the children not breastfed at the time of the interview, only 63% receive any dairy products at all (Table 3). Sixty percent receive vegetables or fruits, and all receive some form of grain or starchy vegetable. In contrast to breastfed children, 52% receive meat or other high-quality protein foods such as beans. In general, meat and grain consumption is higher for non-breastfed than for breastfed children, but consumption of vegetables and dairy is lower.

While the percentage of people receiving particular food groups is an important measure of balanced diet, it is even more relevant to look at the extent to which diet is not balanced. This is important not only for preschool children, who are at risk of stunting and protein deficiency, but for women, who provide a significant proportion of the agricultural labor. We have therefore examined the percentage of our sample missing one or more of the recommended major food groups.

For women, an average of 30% were missing one of the four major food groups. This was most often the dairy group, in that there is a widespread belief that women should not drink the milk from their husband's cattle. Fifty-seven percent were missing two food groups, and 9% were missing three. Only one person was missing all four of the major food groups on the day surveyed. This indicates that two-thirds of the sample of women had diets that were significantly lacking in recommended foodstuffs.

While the diets of children are somewhat more balanced than those of women, a high proportion of children are also missing major food groups. Forty-four percent of the entire samples of children were missing one major food group, most often meat and legumes. Thirty-five percent were missing two food groups, and 6% were missing three. Table 4 summarizes these figures. On average 96% of women and 85% of children were missing one or more of the recommended food groups. Further, 66% of women and 41% of children were missing two or more of these groups.

Overall, these figures confirm the impression of a rural diet that is high in carbohydrates, particularly starch, but is deficient in many other items. The monotony of diet is particularly marked for women, although the lack of variety in the diets of non-breastfed children is also a cause for concern. Seasonal availability of milk, fruits, vegetables, and legumes are obvious areas of potential agricultural concern in rural Swaziland.

Table 4

PERCENT SAMPLE MISSLING ONE OR MORE GROUPS
BY MONTH

# Groups Missing	February	March	April	May	Average
Women:					
1+	97	95	98	97	96
2+	65	71	61	73	66
Children:					
1+	76	86	92	85	85
2+	26	40	45	52	41

Implications for Agricultural Research

While this analysis is necessarily preliminary, being based on selected portions of the total data for only one-third of the year, it raises some interesting points. For late summer and the harvest period, the dietary picture which emerges is one of decreasing variety, primarily due to the disappearance of household milk supplies and many species of edible wild foods. The wild foods most frequently used appear to be the edible wild greens, although there is also a relatively frequent use of wild fruits, particularly by children. While fruits and vegetables are expected to appear in greater frequency at the end of winter, due to irrigated gardening, late summer and the harvest season are times of nutritional concern.

The Horticulture and Agronomy Sections of the SCSRETP have become interested in ways to increase the variety of fruit and vegetable crops grown for home consumption. Part of this effort has been directed toward irrigated gardening. Large-scale community irrigation schemes have been fostered for commercial and semi-commercial vegetable production, and individual homesteads have been trained in the use of household wastewater for small backyard plots. There is now an interest in better production and utilization of high-protein vegetables, particularly beans, and in expanded production of leafy greens.

Production of high-yielding bean varieties is especially interesting to the Ministry of Agriculture and Cooperatives (MOAC). Soybeans have been shown to yield up to twice as much as local bean varieties under Swazi conditions, but there is some concern as to their acceptability as food. To increase their local acceptance, the Home Economics Unit of MOAC has begun an educational campaign to teach local women appropriate methods of processing and cooking. A recipe booklet has been produced, and demonstrations of processing and cooking methods are held at Farming Training Centers around the country. The products of these demonstrations (soymilk, porridge, muffins, doughnuts, etc.) appear to be eagerly consumed, but it remains to be seen whether the average rural Swazi will adopt the technology.

The potential impact of herbicide trials on intercropping and the production of edible greens has also received some attention by the SCSRETP. We are currently interested in finding a time for herbicide application which would only remove edible weeds once they are past their peak of palatability. An alternative to this approach emphasizes the planting of domestic species which would yield significant amounts of edible leaf mass at the time when contact herbicides are applied to weed "gardens." We are now interested in finding domestic species which would have both the requisite taste characteristics and nutritional content to substitute for wild varieties. Since wild species used are generally high in minerals and protein, and since many Swazi diets are low in these elements, this is an important consideration.

Future analysis of the food consumption survey will concentrate on expanding the preliminary results reported here. Food group analysis will be extended to other seasons of the year to produce a complete yearly picture of fluctuation in dietary variety. This analysis will also be expanded to include individual varieties of food within the food groups. We will be particularly interested in the pattern of legume use, as well as that of starchy vegetables and wild and domestic leaves. In addition, we will look at amounts of foods used to gain an approximate idea of dietary adequacy and potential food demand.

As these analyses become more refined, we may then be able to link consumption characteristics with specific aspects of the production system, in order to better define recommendation domains.

All of these activities are seen contributing to the research and extension program of the Cropping Systems Project. Despite initial skepticism, MOAC officials have also begun to recognize the utility of including a nutrition component within their program of agricultural research. By our ability to identify nutritional gaps in rural diets and to recommend production solutions to these, we hope to contribute to the eventual improvement in quality of life on Swazi Nation Land.

ACKNOWLEDGMENTS

Support for this research was supplied by USAID and the Swaziland Cropping Systems Research and Extension Training Project. The authors would also like to thank Sophie Luzecky and Phindile Malaza for their help.

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The Amazon Basin Food Project: An Integrated Approach

J. F. Kientz

The Amazon Basin Food Project was started in 1982 in Tocantinopolis, Goias, Brasil. The original intent of the project was to raise vegetables, however, it was found that poor people would not buy vegetables because they did not know what they were and didn't know how to prepare them. Thereby the project became involved in marketing and teaching people how to prepare foods. Since it was necessary to bring people together to taste foods, it was decided to have lectures and discussions about nutrition before the people tasted the foods. This nutritional education is more to give direction than to purvey factual information.

Description of the Region

The climate of the region is six months of dry, hot weather followed by six months of rainy, hot weather.

The land is covered with trees and grass. A large number of the people live in small villages and on farms. Farmers often grow rice, beans, corn, cassava, squash, and watermelons. It is very difficult sometimes to obtain transportation for the products going to and from the isolated rural areas.

There are three cultures in the region; the traditional Nordestino, the modern culture from Southern Brazil, and the indigenous culture. The recent immigrants have not fully recognized the potential advantage of the crops that are native to their new habitat.

Malnutrition in the Region

Survey information was collected on 120 poor families. The amount consumed per family per week for 51 common foods was obtained. Not all of the foods were included in the survey (especially the seasonal fruits). All data was collected on food in its raw state. Cooking losses for the B complex vitamins, some minerals and vitamin C were not included. This information is not intended to be extremely accurate, but to give insight to the direction the project should take.

According to the survey, the percent of the poor families above the recommended daily allowances are:

Calories	70%	Protein	68%	Vitamin A	25%
Calcium	7%	Phosphorus	82%	Iron	29%
Thiamine	31%	Riboflavin	59%	Niacin	51%
Vitamin C	53%				

Ten percent of the poor families have a serious deficiency in calories.

Sixteen percent of the poor families have a serious deficiency in protein.

The biggest deficiencies are with calcium, vitamin A, B complex vitamins, and iron. Over half of the poor people do not consume fifty percent of the recommended daily allowances in calcium and vitamin A.

During the four months of November through February, there are a large number of seasonal fruits. Here are some examples: Pequi is twenty times stronger than carrots in vitamin A. Buriti is six times stronger than carrots and also high in iron and calcium. Acai is very high in iron. Cashew fruit is three times stronger than oranges in vitamin C. Native mangoes have both vitamin A and C and are eaten in very large quantities (more than 2kg per day per person). The people accumulate vitamin A in these four months that can be used in later months. There are many types of fruit trees that bear fruit at other times of the year. They contain mostly sugar, water and some vitamin C.

Twenty-seven percent of the children born to the 120 families studied, died. It is very difficult to associate the causes of death with malnutrition. Many mothers, whose families seem to have good nutritional and financial status, have lost several children, while other mothers with poor nutritional and financial status were able to keep their children alive. When one compares rich families with poor families, it is easy to detect causes of death. But when one compares poor families who have lost children with poor families who have lost none, it becomes very difficult to determine the attributed cause.

Arm circumference was measured on several small children. The arm circumference was never found below 14 centimeters. None of the children appear to have wasted bodies. Many were stunted. According to W. Keller,4 stunting is caused by frequent and prolonged illnesses.

There are many conditions that are associated with poverty that are often overlooked. For example: contaminated water, improper sewage disposal, failure to boil water for babies, dirt floors, improper hygiene, worms, malaria, tuberculosis, lack of medical facilities and doctors, insufficient breathing space in the children's bedroom, bearing one child right after the other, bearing children at an early age, and having a fatalistic view about life.

Many of these conditions involve bad personal habits.

Nutrition Education

Education is the process whereby behavior is changed. It is not just the dissemination of information.

The stages of education from a student's perspective are the following:

1. Receive information.
2. Evaluate information according to one's needs.
3. Experiment.
4. Practice - Practice - Practice.
5. Forming a new habit.
6. Evaluate the new habits in respect to other habits and plan for future changes.[9]

The educational philosophy of the project is: first, examine thoroughly the causes of the problems by looking at medical records and having personal interviews with poor women; second, design educational materials that are relevant, simple[6&8] and something they don't already know; and third, carry through until the students have formed a new habit.

The project disseminates information to the poor through lectures and brochures. Project staff members assist mothers in evaluating this information according to her needs. The project staff evaluates the mother's behavior changes once a year.

The project does not have the staff or the money to assist mothers with the total educational process, so concerned neighbors , friends, or relatives have to support the mother's attempts to form a new habit. The project trains concerned citizens to help their neighbors to experiment with new ideas and practice new methods.

The project spends considerable time in teaching values such as community pride, concern for others, the importance of a life of a child, and the importance of the impact that one peasant can make on the world.

Since 27 percent of the babies have died, the project has four lectures that are related to this problem. The titles of these lectures are:

1. Feeding a baby.
2. Feeding a sick baby.
3. Hygiene.
4. Feeding Pregnant and Lactating Women

The lectures last about 40 minutes and are followed by the tasting of new prepared foods which could improve their diets.

There are two group discussions involving poor people. They are called nutrition and family economics.

The nutrition discussion consists of a statement of the nutritional problems in the community and their solutions, followed by a discussion of what solutions are best for the community. Balancing of the diets is not

included because survey results showed that if the food was available, or if the poor had enough money, 90 percent of these people would have a balanced diet.

The family economics discussion includes such things as: finding bargains, emphasizing the concept about "cheapest" is not always the "best", finding additional sources of income, how to make food become more available, examining possibilities of a community or privately owned store in the neighborhood, and discussing the economics of a home garden, community garden, or a small commercial garden.

A number of foods are sampled at these meetings. Afterward many women have indicated an interest in learning new recipes. A project staff member first demonstrates about how to prepare a food to a small group of women. Also staff members assist mothers individually. Concerned citizens are trained to assist mothers who do not know how to read, to prepare new foods. Illiteracy is a major obstacle in learning to prepare new foods.

Marketing

It is important to realize that it is food in the stomach that saves lives and not just the idea that a food is good for a person. There are four questions that must be answered affirmatively before a food can be promoted as a solution to a nutritional problem. The questions are:

1. Do the families need it?
2. Do the families want it?
3. Can the families afford it?
4. Is the food available?

Getting an affirmative answer to all four questions may be very difficult. There are some people in the community that are doing a good job of balancing their diets with a very small amount of money. The author suggests that these individuals be used as models in determining what foods to promote.

The author recommends the use of native foods because they are generally cheaper. Two exceptions to this rule is wheat flour and carrots. Wheat flour from Kansas is the cheapest source of protein and a very cheap source of energy. Carrots shipped from 1500 miles away are the cheapest source of vitamin A in the region.

The jungle has an abundant variety of nutritious foods. The author does not recommend attempts to introduce foods that are foreign to the region. It is best to introduce foods in which at least a few of the families in the community are already using. These people can give testimonials and serve as a model for others. Presently the foods that fit into this category are sweet potatoes, okra, carrots, peppers, collards, and wheat flour.

Other foods are eaten by almost everybody, but they are not eaten in sufficient quantities. These include eggs, squash, papaya, oranges, dry beans, tomatoes, and dried milk.

One of the major problems is that food is not available. The project has local door-to-door saleswomen. This also gives some extra income to poor women in the community. The project helps communities and individuals to construct small fruit stands in isolated villages. The project works with grocery stores to see that food is always available.

The project obtains foods for saleswomen, fruit stands and grocery stores from the project's commercial garden. It also buys food from other growers and large city markets. The main thrust of the marketing program is to introduce foods and to see that foods are available. At the time of this writing, the project has not been able to reduce prices or the cost of marketing.

Locally Crown Produce

The three ways to produce home grown foods are a small commercial garden, a community garden and a home garden. Which method will be best for the community will depend on technical, anthropological, and economic factors. If most of the community has been built on fertile soil and there are ample water and manure available, then the promotion of home gardens would be best. If there is an individual in the community that believes in hard work and has the ability to manage, then a small commercial garden would be best. If the community structure is well developed and people are accustomed to working together, than a community garden would be best.

Before any type of garden is started, there must be a demand for the vegetables in the community. This has often been overlooked. To be effective, decisions about gardens should be reduced to matters of existing economics. Telling a peasant to plant a garden because it is good for him is very vague. On the other hand, if a person is eating three kilos of tomatoes per week was told he could save two dollars a month by planting 12 tomato plants, it makes good sense. A person should never plant a crop for home use until they are accustomed to eating it.

Tips About a Home Garden

Survey results showed that the people who were able to balance their diets very cheaply consumed only about twelve different foods. They start with only 4 or 5 kinds of vegetables and that is sufficient and much simpler. If a person plants ten or more vegetables, they may have more problems with insects which are not affected by low toxicity insecticides, such as Sevin, or Malathion. Highly toxic insecticides, such as parathion, may have to be used if persons have highly diversified gardens.

It is best not to plant temperate-zone crops in the tropical regions. They will usually yield only about one-third of what they would if grown in the temperate zone. Therefore they are not economical in the tropics. Examples of temperate-zone crops are peas, lettuce, carrots, cabbage, beets, radishes, and potatoes. One should plant tropical vegetables in the tropics.

Examples of tropical vegetables are sweet potatoes, okra, pumpkin, cassava, peanuts, beans, watermelon, tropical peppers, taro, yams, parsley, coriander and chives. Collectively, these vegetables have all the nutrition that the temperate zone crops have.2

There is no reason to have a garden during the time of the seasonal fruits (November 10 to February 15). The people are receiving ample supplies of nutrients from the fruits at this time. This is a time to plant a leguminous cover crop to replenish the nitrogen and organic matter into the soil. Since it rains very frequently during this season it is not a good time to grow vegetables anyway.

Summary

The Amazon Basin Food Project deals with all the activities between the preparation of a seedbed and the eating of the foods to produce better health. It is a philanthropical organization and yet it does not give away food. It believes that the communities are capable of solving their own food problems. Unfortunately, the project will not be officially evaluated until February 1987, five months after the writing of this paper.

The Amazon Basin Food Project is not only a vegetable producing, marketing and educational organization, it is also a communication network. Figure 1 shows how the communication network is structured.

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Communication Network of the Amazon Basin Food Project

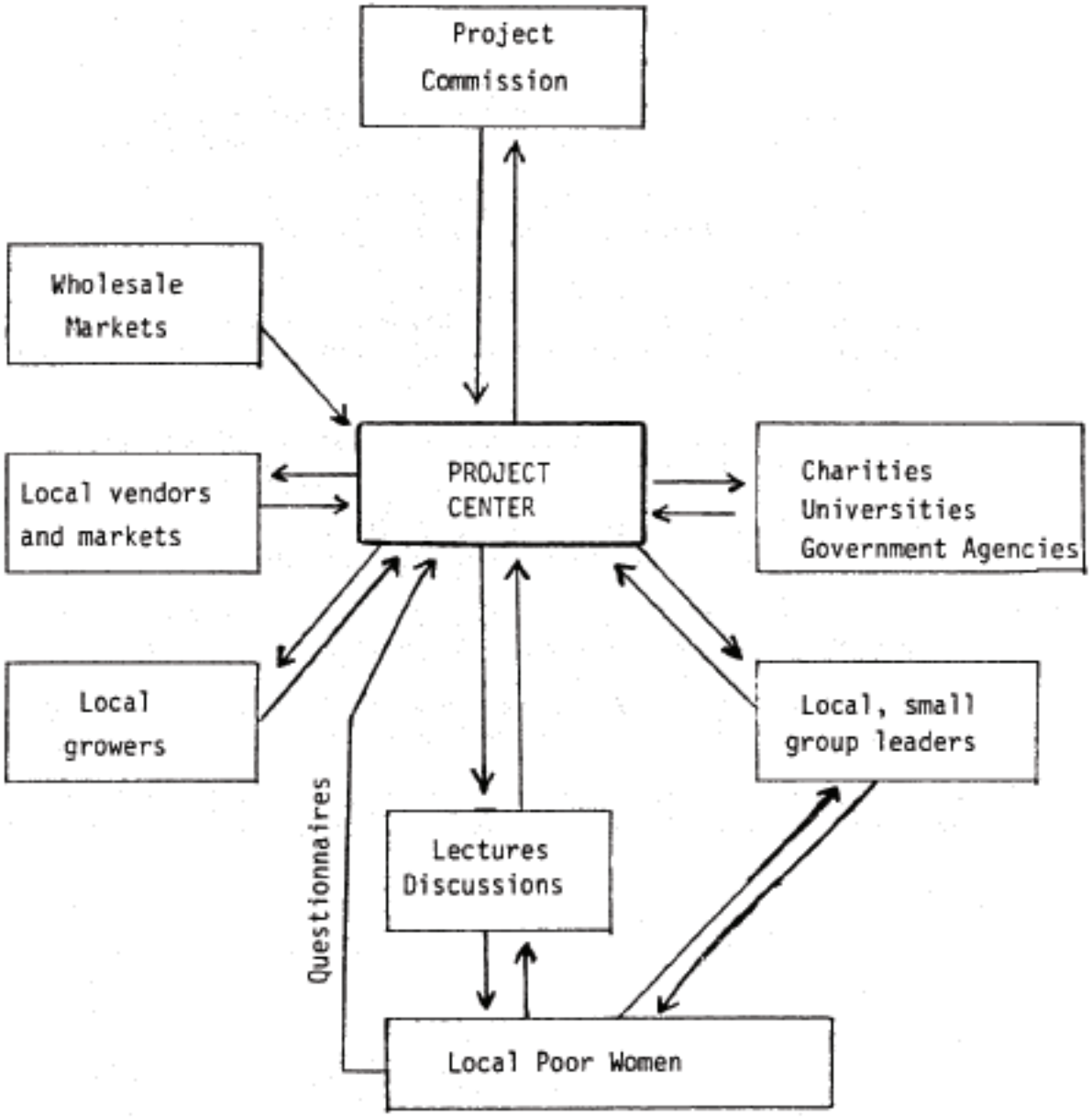

Figure 1.

Private and Common Property Sources of Protein in the Philippines: A Redefinition of the Farming System

Eva Wollenberg

INTRODUCTION

Farming systems research and extension (FSR/E) is conceptually well suited to the study of interactions among agricultural production activities of the household. Although headway is being made in the consideration of relations between livestock and cultivated plants (Paris 1986), little work has been done on interactions among production activities on and off the farm. Off-farm activities affect on-farm activities by influencing how households allocate labor and capital inputs. The interaction can also have effects on household nutrition and income.

Fishing, hunting and gathering are examples of off-farm activities that have received particularly little attention in FSR/E. These are enterprises based on common property resources that are conventionally not included as part of "the farming system." Current definitions of farming systems focus on resources under direct control of households or individuals rather than communities (Caldwell 1984, Nyhus and Massey 1986, Paris 1986). If the farming system is redefined to include all productive activities undertaken by the household, then the relations between group managed resources, such as grasslands (see Diello and Nagey 1986, Fernandez 1986), forests, lakes or seas, and conventional farm resources (e.g. crop lands) can be analyzed for their combined effect on household production and welfare.

This paper shows how off-farm production activities interact with on-farm production activities and have a subsequent impact on household nutrition. Data on fishing, corn production and protein consumption in Balinsasayao, the Philippines are presented. The analysis shows that inter household differences in protein status reflect corresponding differences in food strategies. The strategies vary in their use of off-farm and on-farm resources. Understanding the behavior underlying off-farm resource use, such as common property resource use, contributes to (1) a more comprehensive picture of farming system inter-dependencies and (2) a better information base for the management for the sustainable productivity of all household resources.

COMMON AND PRIVATE PROPERTY IN FARMING SYSTEMS

Little work has been done with respect to nutrition and the household's simultaneous management of common and private property resources. FSR/E studies of common property resources

have concentrated almost exclusively on pasture lands used for livestock (Diello and Nagey 1986, Fernandez 1986). These studies give more attention to the common property activity itself, rather than how the activity fits into the larger scheme of household concerns.

Other research has examined the interaction between common and private resources, but not with respect to household agricultural production (Anderson 1983). Equally few studies have examined the impact of common property resources on nutrition. Asibly (1974), for example, asserted that about 75 percent of the African population south of the Sahara depends on wildlife as sources of protein, but did not discuss the property arrangements that govern their use and management.

The lack of previous work in this area may be largely because of definitions in FSR/E that have restricted been to production activities based on high inputs and household land resources. These definitions overlook the nature of the household as a decision making unit that allocates its labor among competitive activities, both on and off the farm. In the case of common property resources, the dearth of previous study may also be due to the difficulty in observing and understanding the subtleties of group behavior. FSR/E studies have placed heavy emphasis on the household as a unit of analysis. A broader definition of farming systems is necessary if equal treatment is to be given to both on and off farm enterprises. If the word "system" is to be taken seriously, then off-farm activities, (where they exist) need to be included in FSR/E studies.

This paper is organized into four sections. The following section provides an overview of the site, the project and research methods. The second part describes fishing and crop production systems in Balinsasayao. Household food strategies and interactions between corn and fish production are examined in the third part. Finally, the conclusion discusses the implications of the analysis for development activities at Balinsasayao.

RESEARCH CONTEXT

Site Background

Balinsasayao is a small community of slash-and-burn farmers in the southeastern portion of the island of Negros (Figure 1). Approximately 30 households live within a five kilometer radius of two lakes, Lake Balinsasayao and Lake Danao. The lakes are surrounded by an upland Dipterocarp forest which is part of the last remaining contiguous forest area in Negros. Farmers' fields are located in patches within the forest.

The average land area managed by each household is about five hectares; land holdings range from .1 to 21.5 hectares. Household

production is subsistence rather than market oriented, and depends on family labor. Few sources of off-farm income are locally available. Commercial pesticides or fertilizers are used infrequently.

The volcanic soils are acidic (pH range of 4.7 to 6.1), high in organic matter (between 2.9 and 22.7 percent), and have textures that range from clay to sandy loam. Fertility is noticeably higher in fields that have been newly cleared from the forest, not cultivated intensively or have been abandoned for more than a year.

Annual rainfall, recorded for the period June 1982 to June 1985, was between 2000 and 3000 mm. The rainy season is from June to January. Temperatures range from an average of 18 C at night to 29 C during the day.

Lake Balinsasayao is about 100 hectares in surface area, and Lake Danao is about 10 hectares. They are deep, "drowned valley" lakes reaching 100 meters in depth. Almost all fishing and other lake uses occur in Balinsasayao due to its larger size and greater accessibility. The lakes are at an elevation of 850 meters. They are nestled among the volcanic outcrops of a mountain range that runs through the middle of the island. The elevation of the surrounding peaks ranges from 760 to 1790 meters. All fishing activities reported in this paper refer to Balinsasayao unless otherwise noted.

A second area commonly used for fishing is a swampy pond located one kilometer northeast of Balinsasayao. The tanke, as it is known locally, is one kilometer northeast of Balinsasayao. It is only approximately one hectare in size and very shallow (1-2 meters). Several families regularly fish in the tanke.

Project Background

Silliman University, with funding from the Ford Foundation, began a development project in the area in 1981 with the objective of improving the sustainable productivity of the Balinsasayao farms. Efforts have included dispersal of trees for agroforestry, introduction of erosion control measures, organization of an "Upland Farmers' Association" and "Mothers' Group," and crossvisits to other communities to improve the network of communication about innovative farming practices.

Methods

This paper draws from the work of three phases of research in Balinsasayao. The research became increasingly focused with each phase. Silliman conducted an initial survey in 1982 of the "greater" Balinsasayao area. This area included 680 households in the seven barangays (political subdivision of municipality) nearest the lakes. Sixty-eight households were randomly sampled

and surveyed with formal questionnaires during a two month period. This work provided the foundation for intervention designs.

The second phase of research produced information about farming, deforestation and household activities within Balinsasayao "proper" (the area approximately within a five kilometer radius from the lake containing about 30 households; henceforth referred to as Balinsasayao). Each researcher used a combination of surveys, informal interviews, and participant observation. These studies ranged from six months to one year in length.

Research in the most recent phase has been coupled with extension efforts. For example, the project nutritionist measures the height and weight of the children while giving mothers advice about diet. The social worker collects fish production data while catching up on current community problems. The activities in this phase have focused on Balinsasayao proper. Some activities, such as the nutrition study, have built upon the findings of the earlier phases. Much of the work has been continuous for over a year. More details about the methods used in each study are listed in the appendix.

RESEARCH FINDINGS : HOUSEHOLD NUTRITION

The farmers in Balinsasayao have a diet of primarily corn grits, fresh fish, dried (bulad) or salted (guiñamos) fish, boiled vegetables and root crops. The preferred carbohydrate of farmers in this area is corn rather than rice.

Protein intake was 86-100% of recommended daily allowance (RDA), according to the 1982 survey (Fontelo 1983). Protein was primarily from plant sources, which contributed 75 percent of total protein. Animal sources (mostly fish) contributed 25 percent. Com constituted the bulk of total protein. A nutrition study of the Western Visayas region, which included Negros Oriental, showed that the ratio of plant protein to animal protein was 2:1 (Food and Nutrition Research Institute 1968b). The 3:1 ratio in the greater Balinsasayao area is thus higher than the average for the region.

Corn was not only the farmers' primary source of protein, it was also their primary source of calories, iron, thiamine, riboflavin and niacin. The grain provided 62-81 percent of calories and 43-64 percent of protein (Fontelo 1983). Farmers commonly rely on a mixture of complementary foods to give them adequate amounts of protein. For example, corn is an incomplete protein because it lacks the essential amino acids lysine and tryptophan. Complete protein is obtained by complementing the corn with legumes, which have lysine and tryptophan, but are deficient in methionine and cystine. Fish, meat and eggs are complete proteins. The data in this report show grams of protein intake rather than protein composition. Complete evaluation of protein sufficiency relies on both the quantity and quality of protein intake.

Harvey's 1985 study was based on the smaller group of households in Balinsasayao proper. He found (unpub. data) that average protein intake was 92 percent of the RDA (an average of 51.67 grams per person per day). Table 1 shows that corn and fresh fish were the most commonly consumed protein sources in Balinsasayao. Corn contributed an average of 42 percent of protein intake, while fish contributed 12 percent.

Harvey's data show that protein consumption varies considerably among households. Forty percent of the households had protein intakes less than 80 percent of the RDA while another 40 percent had protein intakes greater than 140 percent. The disparity in protein intake among households suggests that stratification of the population according to protein intake might indicate different strategies of protein production.

Table 2 shows interhousehold differences in protein sources. Households with less than 80 percent RDA protein received 36 percent of their protein from corn and 7 percent from fish. Most of the fish was from the lake (6 percent) rather than purchased (1 percent). These households eat a proportionally larger amount of root crops and vegetables to fulfill their protein needs. Root crops and vegetables generally have the poorest quality as well as the lowest quantities of proteins.

Households with greater than 140 percent RDA protein received 46 percent of their protein from corn and 9 percent from fish (3 percent from the lake and 6 percent purchased). The higher level of purchased fish suggests that these households have greater amounts of cash. The high percentage of corn consumption indicates that either (1) these households produce more corn than the other two groups, or (2) they have more cash with which to purchase corn in the market.

In both cases, protein intake appears to be positively associated with the economic status of the household. The high proportion of beans (a cash crop) in the diet suggests that these families grow a substantial proportion of cash crops. Cultivation of cash crops enables households to afford items such as dried fish and corn grits in the lowland market. High economic status is also suggested by the consumption of meat. Although meat is consumed only on special occasions, it is consumed more frequently by better-off households.

The "middle" group of households, with 80-140 percent RDA, have the highest levels of fish consumption. The data show that these families get 43 percent of their protein from corn, and 31 percent from fish. Like the high protein households, these families buy most of their fish (20 percent) rather than spend the time fishing (11 percent). The food strategies of each of these household groups is examined further in the discussion section.

The two initial nutrition surveys were based on 24 hour diet

recall, meaning that information was limited to three to four meals per household. To get a better picture of meal patterns over time, I collected data on 58 meals over 24 days from one household (Figure 5) . My 20 month case study of that household suggest that these 58 meals were fairly representative of the normal diet. The data shows again that corn and fresh fish were the two most common day-to-day sources of protein in Balinsasayao. Dried fish was the third most common source of protein.

In sum, corn and fresh fish are eaten on a daily basis in Balinsasayao among most households. While these are two primary sources of protein, they are not substitutable proteins. Corn and fish tend to be eaten together. In addition to protein, corn provides a high number of calories in the diet. Fish provides a higher quality protein that does not require complementary sources. Inter household differences in nutritional status indicate that protein intake and production varies among households. The following section is a closer look at how households actually achieve these levels of protein intake through fishing and corn cultivation.

RESEARCH RESULTS: PROTEIN PRODUCTION

Fishing

Household fish "production" at Balinsasayao depends on (1) the condition of the lake and its fish population, (2) the time that the household can afford to spend fishing, (3) the farmer's property rights to shore areas, (4) the distance of the farmer's home from the lake, and (5) household access to different techniques of fishing.

The lake and *tanke* contain tilapia (*Tilapia mosambica*), milkfish (*Chanus chanus*), carp (*Cyprinus carpió*), mudfish (*Ophicephalus striatus*), and a species that it is locally known as *hito* (no scientific name available). Most of the lake fish reside in the shallow shore areas. Other parts of the lake are too deep to maintain the primary productivity necessary for fish survival. Local residents say that the fish population varies from year to year with the lake's water level. Higher waters submerge shoreline vegetation and create a more nutrient rich environment that helps to increase the total number of fish. Lower waters leave a rocky, less rich environment.

Despite the importance of fresh fish in the diet, proportionally little of the Balinsasayao farmers' time is spent fishing. Table 4 shows that households spend only 3.8 percent of their time fishing. This is in contrast with crop cultivation (landpreparation, weeding, harvesting, planting), which occupies nearly one half of household time.

Table 5 shows that fishing is done most frequently by males and children between 9 and 16 years of age. Fishing is a "spare time" activity for most Balinsasayao residents. Children and locally recognized "lazy" farmers are often seen spending long hours on the lake. Mudar (1982: 96) observed that fishing at Balinsasayao is often "a playful activity by children, who would still be too young to participate in strenuous agricultural labor," but whose efforts contribute to household nutrition. Farmers say that fishing allows them to socialize and relax. Sundays are usually the busiest fishing days at the lake.

Attempts to increase fishing activities therefore have to recognize the existing division of labor and the prevailing attitude about fishing as a "lazy" person's activity. Since farmers prefer to spend their working time in crop cultivation, reduced time demands or improved fishing techniques might make fish production more competitive with crop production.

Approximately six households have maintained residence on the lake shore at any one time since 1984. These families have greater round-the-clock access to the lake. They (1) fish more often, (2) use a greater variety of techniques, (3) fish individually, and (4) tend to concentrate fishing activities in one area, often with the use of stationary methods such as the gill net and weir. Fishers from other communities tend to (1) fish less frequently, but for greater lengths of time, (2) use the fishing rod or hook and line, (3) fish in groups and (4) to utilize several areas of the lake. Tables 6 and 7 compare fishing frequency and period for farmers from Balinsasayao and farmers who come from outside the community.

The lake is used frequently by farmers living in nearby communities. Although local residents will say that anyone can fish anywhere in the lake, there are subtle rules that control fishing activities. For example, the lake shore households seem to have territorial rights that permit them to establish relatively permanent fish collection devices, such as the gill net, in the coves nearest their home. Other farmers avoid these areas. There is a rule of "first come first serve" with respect to placing of fish traps in other parts of the lake. One does not disturb the fish traps of another person, or place his or her trap near someone else's. There are rarely disputes or conflicts over fishing in the lake.

Only two households live on the shore of the tanke. Three more households live nearby. The use of the tanke follows the same principle of territorial rights used at the lake. Indeed, the tanke is so small that the nearby households are the only ones usually using the lake. Other households seem to prefer the aesthetics, larger surface area, and reportedly greater amounts of fish in the lake. There has been at least one incident where fishing rights in the tanke were disputed. In 1984 an absentee land "owner" claimed that his fishing rights were superior to those of the squatter who was living on his land. The case was

brought to court. The court ruled that no one could claim exclusive use of a body of water. The previous system of informally recognized territorial rights and "first come first serve" was thus resumed.

The farmers use several methods to catch fish (Table 8). The most common technique is the fishing rod. People use this method from the shore and from dugout canoes. Several types of fish traps, the hook and line, spears, fish corrals, weirs, gill nets, seines, dip nets and hand capture are also used.

Average fish yields are .30 kilograms of fish per hour of fishing per person (Cadelina and Dioso, unpub. data). Yields vary with the technique of fishing. People are able to catch more fish in shorter periods of time with the gill net. Fish traps also require relatively little labor per kilogram. The fishing rod is the most time consuming and least efficient method of fishing.

Two households maintain small (less than 20 square meters), fish ponds on their fields. Fish are collected with a dip nets or by hand. The ponds are kept largely for back-up supplies for the exclusive use of the household. They are used on days when there is no one available to fish, no time to check traps and wait for fish to bite hooks, or the number of fish is lower than usual.

Farmers also collect small amounts of fish, crab and shrimp from local streams.

Corn Production

The Balinsasayao farmers cultivate a large number of species that are used mostly for home consumption. Corn (*Zea mays*), sweet potato (*Ipomea batatas*), cocoyam (*Xanthosoma spp.*), cassava (*Manihot esculenta*), taro (*Colocasia esculenta*), cocoyam (*Xanthosoma violaceum*) chayóte (*Sedium edule*), squash (*Cucurbita maxima*), abaca (*Musa textilis*) and a variety of fruit trees are commonly grown (see Table 9). Corn is the dominant crop cultivated by most households. Twenty-two percent of all fields were planted to corn in 1984. Farmers describe corn as their most important crop as well as the most difficult crop to cultivate.

Corn demands more labor in land preparation, planting, maintenance, harvesting and processing of than any other crop except rice at Balinsasayao. Most households weed their corn fields daily during the first two to three months after planting. The farmers place a higher priority on weeding their corn fields than on weeding other plots. Households describe the period of corn planting and weeding as the most labor demanding time in the agricultural calendar. Corn is harvested after four months, dried, and ground with a millstone at home.

Tables 11 and 12 show the age and sex distribution of weeding,

planting, and harvesting activities for all crops. Much of this work, particularly the weeding, was directly related to corn production since the data was collected between February and August. The tables show that these activities predominantly performed by males. Planting and harvesting was usually carried out by adults, while weeding was done largely by children ages 9-16. Children in this age group therefore make significant contributions to household protein, both in terms of fishing and corn production.

Corn is planted under three types of tenure arrangements: ownership, share-cropping and family sharing. Table 10 shows that the majority of corn fields, seventy percent, are "owned". Owners have rights to all of the yields from their land. Although all of the land technically belongs to the national government, the farmers sell, buy, rent and trade land as if they had actual title to the property. Despite their official status as squatters, few farmers believe that the government will ever take the land away from them. In fact, it is likely that the Philippine Bureau of Forest Development will give the farmers stewardship contracts that assure the farmers of at least 25 years of land tenure security.

Only 17 percent of the corn fields are share-cropped, according to Table 10. Sharecroppers have the right to use of the land, but are obligated to pay the landowner some proportion of the crop yields (usually one quarter to one third). Some sharecroppers are squatters even from the perspective of the community, i.e. they do not give a share of the crop yields to the landowner. This is usually because they are either using the land for too short a period for the landowner to take notice, or because the landowner did not request payment.

Shared family plots are the least frequent form of land tenure for corn fields at Balinsasayao. They constitute only 13 percent of all the corn fields. Farmers share rights of use with other members of their immediate family. The fields are usually sites that parents have allowed their adult children to use. Plots within the field are managed by individual households rather than groups of households. At some point, usually after the parents die, the land is divided into "private" lots, and each partner becomes an owner.

Households in the advanced stages of the family cycle tend to share almost all of their lands with the newly formed households of their sons and daughters. This property arrangement is a way for the parent household to maintain security and control over land without extracting rent. Land is gradually transferred to the children's households as the parents' consumption needs and labor supply decreases.

Although the first two tenure categories are not strictly "private property," these lands are used and managed by a single party rather than by groups. The stream of benefits is independently controlled by each household. Corn production by

one household does little to affect corn production of another. In contrast, the water resources are shared. Fish and water are mobile; fishing or pollution of the lake has a direct impact on the ability of others to collect fish. Thus, the land resources are considered private property resources relative to the lake in this paper. There are, however, differences in farmer decisions associated with each of these land tenure types that need to be considered in the design of appropriate development interventions.

The amount of corn planted by each household varies considerably. Households used an average volume of 1.23 liters of grain to plant an average of .74 hectares of corn in 1984. Small amounts of young corn (anagon) are harvested to be eaten as a vegetable or snack before the final harvest of corn. No data is available on corn yields, although it is known that none of the households produce enough corn to satisfy their consumption needs for an entire year. Home-produced supplies of grain last between one and six months. Households then purchase their corn on a weekly basis in lowland markets.

Families sometimes have difficulty finding the cash to purchase corn. Of the eight households with low protein RDA's, six of them said that they suffered food shortages for at least three months out of the year. These months were most often May, June and July, i.e. the months just before the corn harvest. Two households said that they were short of food all year long. In contrast, fewer households in the other RDA groups (three in the middle range households and two in the high range households) said that they suffered food shortages during the year. These households also listed fewer months of shortages.

Since households purchase corn once their own supply is exhausted, a complete analysis of how household's supply their protein would include household expenditures for purchased grain. Other items in the farmers' diet that contain protein (e.g. beans, eggs, domestic livestock and wild animals) would also be included. Such an analysis is not, however, the purpose of this paper. Rather, the purpose of this paper is to show how a broader definition of farming systems allows one to examine interactions between off-farm and on-farm sources of protein. Consequently, the paper limits its analysis to fish and cultivated corn. The way that households balance production of each of these sources is discussed in the following section, with particular attention to interhousehold differences in food strategies.

DISCUSSION: HOUSEHOLD FOOD STRATEGIES FOR FISHING AND CORN PRODUCTION

Although corn and fish are used as a joint source of protein in the diet, households differ in levels of protein intake. The ability of households to supply adequate protein is largely a

function of differences among households in terms of constraints in land resources, crop resources, labor availability, and consumption needs.

Interactions between fishing and corn production are affected by the degree to which the farmer is able to find substitute sources of protein. Fish and corn grits purchased in lowland markets serve as substitutes for lake fish and cultivated corn. Households can therefore choose to cultivate and catch their food, or to earn an income (through market crops or wage labor) that allows them to their purchase corn and fish in the market.

Labor and cash constraints affect how farmers trade off between that which they produce themselves and that which they purchase in the market. Thus, when re-planting and weeding corn fields monopolizes household labor for two months, a household is likely to buy dried fish since they do not have the extra time to spend fishing. If a family's corn crop is destroyed by a typhoon, they are likely to buy corn in the market. Since the farmers have limited amounts of cash, increased outlays for corn might be balanced by decreased expenditures on dried fish, causing the family to meet their protein needs by fishing more in the lake. Cash outlays might also be balanced by growing crops with higher market values.

The balance between corn production and fishing for most households is such that most farmers favor corn production over fishing. Fishing is performed as a secondary activity for most households. Fishing is a primary activity for only for the low RDA households. This may be because farmers find fishing to be a less efficient use of their time than crop cultivation. They might be able to earn high enough returns through crop sales to be able to buy both their corn and fish from the market.

Thus, strategies of protein production appear to be associated with household economic status. Better-off households tend to have more labor and more land per consumer. They are better able to produce their own corn and purchase corn or fish. The households grow a higher proportion of crops with high protein quality and quantity. These crops tend to also have high market values.

The middle level households have less land resources than the better-off households, and cultivate correspondingly lower quantities of corn. The high proportion of fish in their diet is surprising, and may be a coincidence of data and the small sample size of four households. Nevertheless, one might speculate that these households produce enough surplus to be able to buy their fish rather than to spend the time fishing. They might have enough land to cultivate crops, but not the surplus of labor needed for fishing.

Poorer households tend to have correspondingly poorer access and control over resources. Since they do not have the land resources with which to cultivate adequate quantities of corn or

cash crops, they rely more on the self-exploitation of their labor. This labor compensates to some extent for the lack of land resources. They cannot buy fish in the market and therefore they must fish from the lake. The poorer households do irregular weeding, planting or harvesting for the better-off households in exchange for wages and meals. If they work regularly on the neighbor's corn field, the neighbor will provide them with a percentage of the corn harvest (sometimes as a substitute for wages). The result is that the poorer households substitute root crops for corn and rely largely on a diet of root crops for calories and fish for protein.

The very poorest households also tend to avail themselves more often of birds, rats, frogs, snails, snakes, wild cats, large lizards and monkeys. Although these are high protein sources, some (e.g. rats, frogs) are considered very low status foods, and others are extremely time-consuming to catch. In times of great need they request small amounts (less than one kilo) of corn grits from their neighbors or relatives, who then give it to them out of a sense of pity and community obligation.

Households with poor land resources seem to have a strategy that relies more on community systems of reciprocity and community managed resources such as the lakes, streams and forest. These households are unable to exist independently and cannot provide farm inputs outside of their own labor. Projects that are targeted at helping these marginal households need to therefore give considerable attention to the nature of sharing and reciprocity networks in the community. Access to capital and land resources are critical constraints for this group of households.

CONCLUSION

The nature of household nutrition and protein production at Balinsasayao has several implications for future development interventions. First, since farming households operate as systems dependent on a variety of resources, common property resources such as lakes and forests need to be given consideration equal to that of private property resources. The information from Balinsasayao shows that fish are an integral part of the farmers' diet, and fishing is an integral part of household activities. Development activities targeted at improving nutrition would be limited if they considered ways to increase crop or livestock production without also considering fishing practices, or other off farm sources of protein.

In addition, there is significant variation in protein intake among households. Nutrition programs need to recognize that the relations among production systems of different components of the diet vary among households. Households with similar protein production patterns (or other selected aspect of nutrition) can be grouped into research or target domains that facilitate

greater attention to specific production opportunities and constraints. Given the existing nature of protein consumption at Balinsasayao, it seems that households with protein intakes below 80 percent RDA face the most critical protein production constraints. The Silliman project is giving first priority to aiding these households. Greater attention might be given to studying ways to overcome their production limitations.

Finally, the nature of fishing rights in that lake are likely to affect overall fish production in the lake. Information about common property resources elsewhere can provide guidelines for interventions that are to meet objectives such as sustainable productivity without environmental degradation. According to Moench (1986) and Ostrom (1985), effective management of the fish resource would be expected in Balinsasayao as long as the number of users is small and there is equal access to information about the state of the resource. The remoteness of the lake and small number of households result in the effective exclusion of outsideusers.

However, if accessibility were increased (e.g. if the road is improved or if public transportation is introduced) then the residents might have difficulty excluding outside users. Farmers in Balinsasayao proper might become more possessive of the lake and try to exclude the farmers from nearby communities who have always fished at the lake. Similarly, if the number of residents near the lake increased due to migration, one would expect greater difficulty in enforcing the existing set of casual rules. Under such circumstances, fishing rights would be probably become more explicitly defined and institutionalized. Community institutions of resource control are more likely to evolve where there is conflict over resource use (see Wade 1985). The higher level of conflict over fishing rights in the tanke suggests that the similar disputes might occur in the lake if resources should become sufficiently limited.

These types of questions are being given consideration as the Balinsasayao development project enters its fifth year. The poorest households with low protein intake have been targeted for a special food supplement program. There is, in fact, pressure from municipal and provincial officials to improve the road so that tourists would have access to the lake. The farmers want to improve the road and have public transportation to market their produce more easily. Migration from the lowlands has been steadily increasing since the 1950's, and is not likely to stop until small farmers find economic relief through land reform or government aid. In short, land use and fishing are likely to increase in the future. Given the existing system of lake management, environmental degradation is likely to threaten the lake. Common property resources will need to be included in the definition of the farming system if FSR/E development efforts are to attain the objective of improving sustainable productivity for all resources on which the Balinsasayao households depend.

FOOTNOTES

[1] Resources that are exclusively used by only one household in a particular social setting are private property resources (Bromley 1985). Resources that are used by more than household are common property resources. Despite these simple definitions, property rights tend to be complicated. This is because (1) multiple rights may be associated with each resource, (2) more than one individuals or groups of individuals may be using different combinations of these rights, (3) property rights are culturally bound, and are therefore often subtle, covert and changing over time. Lastly, (4) rights are often disputed and unclear even within a culture.

Households are the primary unit of decision making in Balinsasayao. In other areas, the definition might include another entity as the more appropriate basic unit of decision making. There are other forms of tenure besides private and private property, e.g. open access and state property. See Ostrum (1985) for further discussion of the different types of property.

In areas where farmers depend on common property resources, FSR/E projects might be concerned with the degree to which communities manage for the sustainable productivity of these resources. Moench (1986) summarizes the characteristics associated with effective group management of common property resources: (1) the community is a defined group with a sufficient control over the resource to exclude users from outside the group, (2) there are well-defined rules of access within the group and assurance that these rules will be followed, (3) the group has access to information about the use and changing state of the resource, and (4) the group is small or, in the case of larger groups, there are high levels of enforcement and monitoring (see Moench [1985] and Ostrum [1985] for further discussion of these characteristics).

Social conflict or environmental degradation of common property can therefore be expected when these characteristics are weak or nonexistent. The system is also likely to break down as population pressure increases (Jodha 1985).

[2] The nutritional content of food and RDA values were found in tables compiled by the Food and Nutrition Research Institute [FNRI] of the Philippines).

[3] Fontelo's data was not available in a form that showed inter-household differences.

[4] The community is Catholic and considers Sunday to be a day of rest.

Footnotes not cited in original text.

ACKNOWLEDGEMENTS

The author would like to thank Jeff Romm, Jonathan Kusel, Nick Menzies, Louise Fortmann, Rowan Baker, Michael Watts, and John Cordell for helpful comments in the preparation of this report. Rowe Cadelina and Ian Harvey provided much useful information. Virginia Dioso, Ramon Somido and the Batal family helped me to collect data. The author's research was funded with a Fulbright Grant. Any errors in the paper are mine.

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Figure 1 : Map of Negros
(Drawn by K. Rubias)

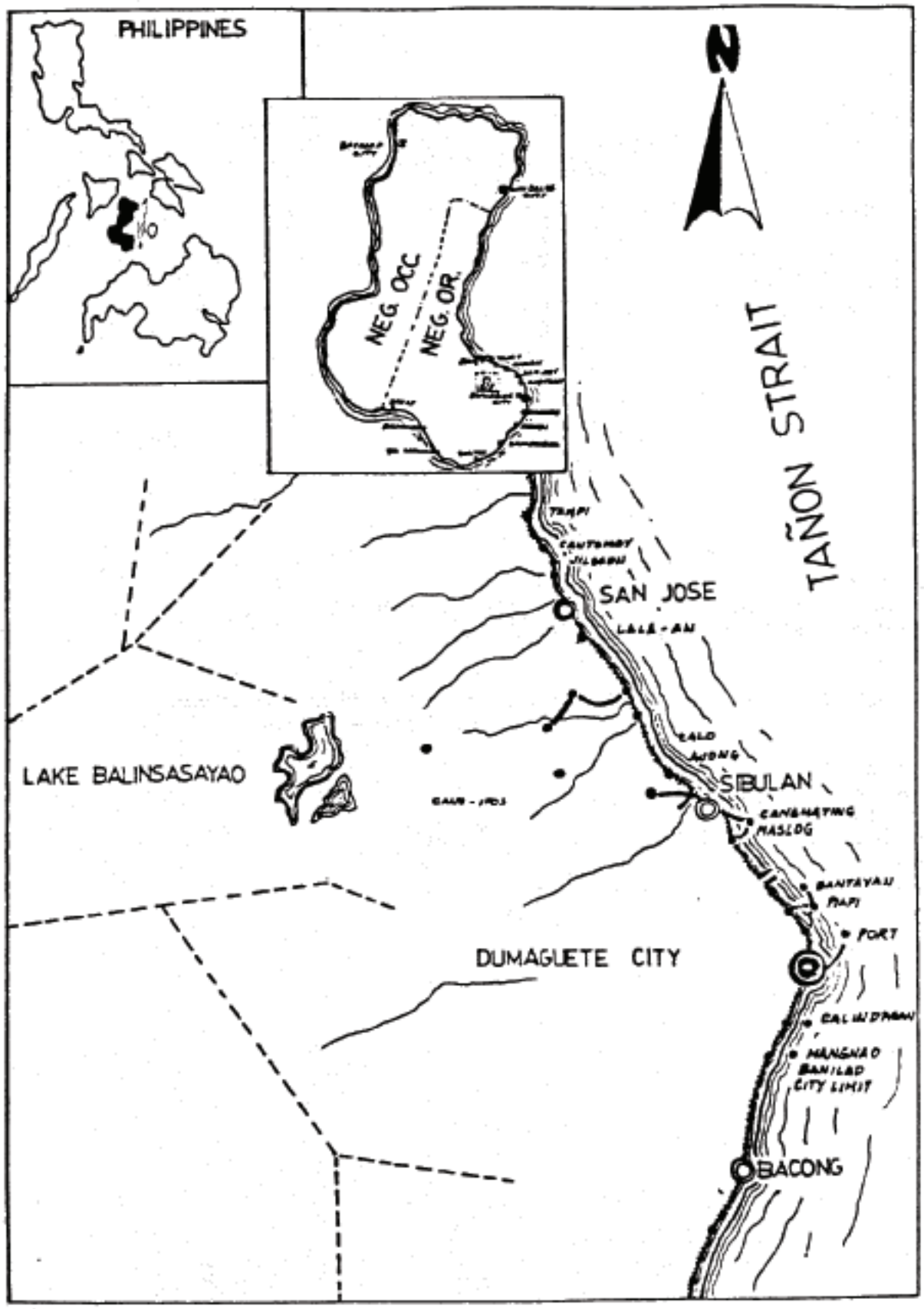


Table 1

Frequency of Protein Sources for 20 Households
(Source: Harvey, unpub. data)

Protein Source	Percent of households that had Consumed this protein in Previous 24 hours
Corn grits	80
Rice	10
Freshwater fish	25
Purchased fish (dried or salted fish)	20
Beans	20
Chicken	5

Table 2

Protein Consumption for a Single Household
(Source: Wollenberg, unpub. data)

Protein Source	Percent of meals that included this protein source
Corn grits	98
Freshwater fish	64
Purchased fish (dried or salted fish)	60
Beans	9
Pork	2

Table 3

Intrahousehold Differences in sources of Protein
(Source: Harvey, unpub. data)

	Household Level of Protein Intake		
	<80% RDA	80-140% RDA	>140%
No. of households	8	4	8
Protein			
Corn (% total protein)	36	43	46
Fish (% total protein)	7	31	9
a. fresh fish (% total protein)	6	11	3
b. purchases fish (% total protein)	1	20	7
Beans (% total protein)	4	3	22
Meat (% total protein)	0	0	6
Other: e.g. root crops, vegetables, biscuits (% total protein)	53	23	17

Table 4

Distribution of Household Time by Activity
(Source: Wollenberg 1986)

Activity	Percent of Time
Livestock	1.7
Land preparation	12.7
Weeding	26.0
Harvesting/planting	8.3
Fishing	3.8
Gathering/forest use	1.5
Processing/manufacture	2.7
Income/exchange labor	7.6
Marketing	7.2
Domestic chores	19.2
Daily needs	5.6
Leisure	1.3
Visiting	.7

Activities included in each category are listed in Appendix.

Percent calculated as time spent by all individuals in each activity divided by time spent by all individuals in all activities.

Table 5

Age and Sex Distribution of Time Spent Fishing
(Source: Wollenberg, unpub. data)

	AGE								
	3-8	9-16	26-29	30-39	40-49	50-59	60-69	70-79	TOTAL
SEX									
Male	4	39	9	5	5	0	0	9	70
Female	0	14	0	16	0	0	0	0	30
TOTAL	4	53	9	21	5	0	0	9	100

Percent was calculated as the total time spent by individuals in each category divided by the total time spent fishing by all people.

Table 6

Frequency of Fishing According to Place of Origin of Farmers
(Source: Cadelina and Dioso, unpub. data)

	Daily	1-2x per week	1-2x per month	“Anytime”	Less than 2x per year
Persons living less than 3 km. from lake	6	1	9	5	0
Persons living more than 3 km. from lake	0	9	12	5	2
Total	6	10	21	10	2

Table 7

Time Periods Spent Fishing According to Place of Origin of Farmers
(Source: Cadelina and Dioso, unpub. data)

	Less than 2 hours	2-5 Hours	More than 5 hours	Average No. Hours
Persons living less than 3 km. from lake	15	12	3	2.4
Persons living more than 3 km. from lake	4	22	18	5.5
Total	19	34	21	4.3

Table 8

Frequency of Fishing Techniques
(Source: Cadelina and Dioso, unpub. data)

Fishing Technique	English term	Frequency of Observations of Use
Bingwet	Fishing rod	44
Birik-birik	Hook and line	23
Solanaw or timing	Basket fish traps	11
Pukot	Gill net	4
Pana	Spear	1

Table 9

Distribution of Selected Crops on Farms Plots
(Source: Cadelina 1983)

Crop	Number of Farm Plots	Percent
Corn	40	63
Banana	34	52
Sweet Potato	12	19
Taro	10	15
Abaca	30	46
Coconut	28	43
Cacao	3	5
Chayote	3	5
Avocado	6	9
Coffee	6	9
Jackfruit	1	2
Beans	5	8
Squash	4	3
Cassava	4	6
Yam	2	3
Total no. lots	65	

Table 10

Land Tenure Characteristics
(Source: Wollenberg, unpub. data)

	Total number of fields	Percent of all fields
All fields	101	100
owned	71	70
sharecropped	15	15
shared with family	15	15
		Percent of all fields ever planted with corn
All fields ever planted with corn	70	100
owned	49	70
sharecropped	12	17
shared with family	9	13
		Percent of fields planted with corn in 1984
Fields planted with corn in 1984	22	100
owned	15	68
sharecropped	4	18
shared with family	3	14

Table 11

Age and Sex Distribution of Time Spent Planting and Harvesting
(Source: Wollenberg, unpub. data)

	AGE								
	3-8	9-16	26-29	30-39	40-49	50-59	60-69	70-79	TOTAL
SEX									
Male	10	10	1	2	31	2	0	2	59
Female	2	8	-	12	17	2	0	0	41
TOTAL	12	18	1	14	48	5	0	2	100

Percent was calculated as the total time spent by individuals in each category divided by the total time spent planting and harvesting by all people.

Table 12

Age and Sex Distribution of Time Spent Weeding
(Source: Wollenberg, unpub. data)

	AGE								
	3-8	9-16	26-29	30-39	40-49	50-59	60-69	70-79	TOTAL
SEX									
Male	3	19	1	3	8	15	10	1	60
Female	*	14	1	0	13	6	6	0	40
TOTAL	3	33	2	3	21	21	16	1	100

Percent was calculated as the total time spent by individuals in each category divided by the total time spent weeding by all people.

APPENDIX: Methods

The material on time allocation, cropping practices, land tenure, day-to-day diet, and contextual information was collected by the author. I used participant observation, case studies and surveys during 20 months spent at the site between 1984 and 1985.

The diet study was based on direct observation of 58 meals consumed over 28 days by the family that I was living with. Data on general household characteristics, farming practices, land and labor resources and sources of income were collected with formal surveys that were administered to 26 households within the 5 kilometer radius of the lake in 1984.

The data for the time allocation study were gathered during a seven month survey of ten households in 1985. The sample represented 71 percent of all households within one kilometer of the lake. Households were visited approximately every four weeks. A total of 53 days was recorded for all households. Activity categories were defined as follows:

1. Livestock: feeding, pasturing, collection of roots for pigs, cooking of roots for pigs, general care

2. Land preparation: plowing, hoeing, burning, cutting vegetation (i.e. kaingin), visiting plots, application of pesticides or fertilizers, related travel

3. Weeding: weeding, related travel

4. Harvesting/planting: harvesting, planting, transplanting, related travel

5. Fishing: setting fish traps, collecting fish from nets, fishing from boat or shore, gathering bait, maintaining fish pond, related travel

6. Gathering and forest use: collection of fuel wood, vines, hunting, related travel

7. Processing/manufacture: sewing, making tools, making baskets, mats, processing tobacco, hand stripping abaca, roasting or grinding food products

8. Income: off- and non-farm labor (includes road construction, sawing timber), exchange labor, abaca sales, related travel

9. Market: local exchange, buying and selling in coastal markets, related travel time

10. Domestic chores: sweeping, washing dishes, child care cooking, preparing food for human consumption, butchering, fetching water, chopping wood, building fire, watching house, laundry, unpacking baskets, searching for items, lighting kerosene lamps, construction or home repairs

11. Daily needs: eating, sleeping, education, dressing, hair cutting, personal hygiene, sickness

12. Leisure: relaxing, socializing, entertaining

13. Meeting: transporting other people across lake, meeting visitors, community meetings, guiding visitors, interview periods, related travel, visiting within and outside the community

Most of the nutrition data in this report was collected by Ian Harvey during six months in 1984-1985. Harvey used 24 hour diet recall with 22 households; only the 20 households that fall within the boundaries of the previous studies are included in this analysis.

The quantified data on fishing practices was from a fishing study by Rowe Cadelina and Virginia Dioso. They collected fishing data every Wednesday, Friday and Sunday for randomly selected weeks beginning in 1985. The study is designed to continue for one year. The data presented in this report are from the first three months of that year and represent 14 days of observation of all fishing activities at the lake. Information from 74 observations of fishing were made during this time. People fishing were interviewed and their catch was weighed,

The most recent nutritional survey (1985-86) has not been completed yet. As part of this survey, weight and body measurements are being been routinely made of all children in Balinsasayao every month. The nutritionist teaches classes at the weekly Mother's Club meetings. Greater emphasis is being given to health problems and preventative care. Households with severely malnourished children have been targeted for special attention. The project recently began giving these households monthly rations of soy powder to supplement the children's diet.

THE EFFECT OF GENDER-RELATED PRODUCTION MANAGEMENT ON THE DESIGN AND IMPLEMENTATION OF PARTICIPATORY TECHNOLOGY VALIDATION[1]

Maria E. Fernandez
Hugo Salvatierra

Introduction

The reasons behind the lack of adoption of improved agricultural technologies by small farmers is a question which research and extension agencies and their field workers continue to ask themselves. Many if not most of the technologies developed on experimental stations have not been incorporated into the production systems of those who produce mainly for family subsistence. During the decades of the 1950's and 1960's, the common explanation for this phenomenon was that the small farmer was too traditional to accept new ways. He or she was thought to be complacent with the status quo, comfortable with their limited standard of living and adverse to change.

Although the most part of crop and animal research is still carried out within the confines of experimental stations, we have come to realize that "traditionality" is not the main reason that the small farmer does not incorporate improved technologies. It is becoming more and more evident that many of the alternatives developed require capital, labor and ecological conditions which the subsistence farmer does not have access to. Taking these factors into consideration, the limitations of research methodologies in use are being reconsidered and institutions such as the International Potato Center and pilot projects within the Peruvian Ministry of Agriculture are attempting to carry out experiments under conditions more similar to those which the small farmer must deal with.

This paper discusses a multi-disciplinary experience in three high altitude peasant communities of the Mantaro Valley in Central Peru, where participative research has been done with men and women farmers over a period of three years. We will analyze some of the alternatives that have been incorporated into experimental designs which take into consideration the farmers' previous technological experience as well as organizational strategies used for production. Our objective is to develop more effective ways of validating crop and animal management technologies which can help solve production problems defined by the farmers themselves.

The Communities of Aramachay

The "Campesino" Community of Aramachay is the hub of nine high altitude (3,500-4,000 meters) communities, at 11° 57' south latitude and 75° 25' west longitude, above the western side of the Mantaro Valley. Daily temperatures range between 26 C and -6 C with the greatest

variation found during the months of July and August. Dryland farming is carried out between September and June as an adjustment to the rainy season which extends from September to April.

The family farming area consists of between 1.3 and 6.8 hectares of arable land, one fourth of which is fallowed at any given time. Some 12 crops are planted during the agricultural season on an average of 28 disperse plots (1/8 to 1/4 hectare) with different soil characteristics and gradients. The principal crops include tubers (potatoes, mashua, oca, olluco), grains (barley, wheat, oats, quinua) and in a few cases maize; frequently planted in associations of varieties and/or species. The varieties as well as crops are selected for their adaptability to climatic conditions as well as to multiple usage in human as well as animal nutrition. Most of the production is destined to farm unit consumption although potato and barley production is partially marketed.

The production system is mixed so that animal husbandry serves as a complement to crop production. Sheep are the most important species, followed by cattle, donkeys and swine, mainly of the "Criollo" (native to the region) breed. The family herd is grazed on communal range lands. Crop residues and some grains serve as supplements, especially in the case of cattle. Oxen and donkeys are used for farm traction while sheep provide reserve capital. The latter are sold on the hoof or as meat, sporadically, when cash is needed. Guinea pigs and chickens are kept for family consumption.

The family unit consists of an average of six members who are the main source of labor. The production unit is organized as a small-scale enterprise in which major decisions are made by adult family members; husband and wife, or, husband, wife and adult offspring. Daily production decisions with sub-units (crops, animals) are made by the adults who are responsible for them; generally, in the case of animals the women and for crops the men. Tasks are shared by all family members depending on requirements within the sub-units of production and are distributed by age and gender according to need and ability. During periods of labor shortage (planting, weeding, harvesting, threshing), relatives, "compadres" and/or friends, form reciprocal labor exchange arrangements called "Ullay". "Ullay" is a relatively stable verbal contract by which several families (about six) work together on a rotating basis on each other's farms. Hired labor is uncommon. When it is used, laborers are paid the equivalent of 13 kg. of potatoes per day per person in addition to "coca", cane liquor, cigarettes and food.

Why Do Participative Technology Validation?

Experimental stations generally have the advantage of being able to control such factors as capital, labor, land area, inputs and even seasonality of water. This is due not only to the fact that the locations are carefully chosen to provide certain climatic and humidity conditions, but to the fact that in most cases the state or international projects provide them with a budget sufficient to cover labor and input needs on a cash basis. This means not only that conditions are

advantageous, but that in the case of the failure of one or another experiment, no one in particular must take on the production loss.

These advantages are not available to the small farmer. He or she most often must work on rain fed land which has either been allocated by the community or is available for purchase within its boundaries. Access to capital depends not only on the capacity to produce, but on market fluctuations which provide him/her with terms of exchange favorable enough to permit for the acquisition of necessary external inputs.

Most important of all, in the labor intensive situation of the small farmer, personnel must be available at the time that it is needed. In the small-scale production system this factor is crucial as all community members are subject to similar labor demands during the same periods of time and neither cash nor salaried labor is readily available for supplementary purposes.

The high altitude small farmer of the Mantaro Valley has designed over time production strategies and organizational forms which aid him to overcome some of the bottlenecks mentioned above. One of these is the complementarity between the crop and animal components of the system which permit greater independence from external inputs. Shortages of labor are overcome in part by the efficient distribution of decision-making and task allocation among gender and age groups within the production unit as well as by shared labor arrangements with other community members.

In order to provide the small farmer with technologies which will improve production then, it is necessary that these be designed to take into consideration the composite of ecological, technological and organizational factors used for small-scale production as well as the biological factors which have commonly been the objective of crop and animal research.

As a result, there are a series of questions the answers to which we consider basic to appropriate research with small farmers:

1. Who is the producer? Who is making the decisions in the production and sub-production units?

2. Which are the principal problems or limitations which the producer is attempting to overcome?

3. How are the production tasks distributed among men, women and children who participate in the process?

4. Which are the experimental designs that will serve at one and the same time to prove the effectiveness of a technology and to demonstrate its benefits and limitations to the producer?

If it is true that the agronomist, animal science specialist, veterinarian and extensionist have a wealth of knowledge concerning biological factors related to production, it is undeniable that the small

farmer has a wealth of knowledge concerning the management of ecological, technological and organizational factors related to production under specific conditions. In addition, in the Andes, where land, crop and animal management systems have been highly developed for at least four centuries the small farmer has access to systematic, historic bodies of knowledge which influence his production practices.

Participative research then, is a means by which two bodies of scientific knowledge can be brought together so that the solution of small-scale farming problems can take place over a shorter period of time, and with greater security that the alternatives found will be adopted. Participation with the small farmer refers not only to a manual contribution for the implementation of experiments and validations, but to an active involvement of the producer in the phases of:

1. Problem definition
2. Design of experiments to solve these problems
3. Implementation according to local cultural practices
4. Evaluation based on the farmer's production criteria

Gender-Related Production Roles

Having decided to validate technologies which the producers of an area think might provide a solution to one or more of their problems, it is necessary to have a clear idea of who will take part in different phases of the process. In the Andean communities where we have experience, we have been able to distinguish four groups of people with varying degrees of experience and decision making power.

1. Production Unit Managers

This group is made up of the adult members of the nuclear or extended family who in consultation, decide on the overall production objectives: what should be planted and for what purposes (consumption, sale, social obligations) during one year and over a period of years; what type and breed of animal should be invested in; which inputs should be invested in; which inputs should be purchased or traded to support the production effort. It is this group which will make the decision as to whether the production unit should open itself or not to trials with new technologies or to the modification of technology in use. Although the elder male member of the group is usually the public spokesman for the decisions made, he alone is not the decision-maker.

2. Sub-unit Managers

The sub-unit managers are those who are in charge of the day to day operation of certain production components. In the mixed production system of the high-altitude Andean communities it is the adult men who oversee the crop component while the women oversee the animal component. This responsibility implies that the sub-unit manager has more experience in specialized areas such as soil quality, climatic conditions, ox-team training (men), and, animal health and

reproduction, range quality and capacity (women). It is at this level that problem definition and design of experiments is most effective. The approval of efforts by the production management group (1) is obtained as a result of the opinion of the sub-unit managers.

3. Task Implementators

We have observed two categories of tasks within the production units with which we work. The first includes tasks which imply a permanent responsibility on the part of adult members of the unit. For example, seed selection and the placing of the seed in the ground at planting is the responsibility of the women while the branding of animals is the responsibility of the men. The second category includes tasks that are assigned temporarily according to need at a given time. In this case, older members of the unit or children could be assigned the task of removing the first tubers loosened at harvest, daily grazing or the administration of remedies and supplementary fodder to the animals. Those who fall into the first category have an active part in the implementation of special techniques needed for experiments and must understand fully the objectives and rationality behind what is being done.

4. Reciprocal Work Group Interaction

This group is important because the families of which it is made up tend to share technological experience and production objectives. Those who participate in shared labor do not work under a vertical direction system but rather implement their own technology in unison, replicating technological and organizational practices on the farms of all involved. For this reason what is tested on one farm, if successful, will probably be repeated on the others. On the other hand, the whole group must be aware of what is being attempted in the experiments from the onset because, together with the sub-unit manager, they are the direct implementators.

It is important to note here that the four groups described tend to be schematic and generalized. In the Andean situation, there are no overt tabus as to who (gender/age) may or must carry out certain activities. Therefore in the case of women heads of households (single mothers, widows, or where the spouse is working elsewhere) the woman will manage the crop as well as animal component of the production unit with the aid of male relatives and friends. Here we do not wish to overlook the many variations which exist, but point out the fact that a complex organizational strategy is used to distribute responsibilities within the unit. Those who have specific technological knowledge and experience, make certain decisions and carry out specific tasks, must be considered to varying degrees in the different phases of the experimental process.

The Experience

The following problems were found when the implementation of experiments was planned with them during the first year.

The small farmer is unwilling to leave areas unplanted as this represents a waste of utilizable land. In addition, portions of land that are not cultivated encourages weed growth. When the land would have been planted with potatoes (second year of rotation cycle), it would have been fertilized which is the basis for the growth of crops in future years. In the case of grain crops in following years, the land left uncultivated will be unfertilized and hard and will not provide the conditions for proper growth. If there is a need for spacing it is only acceptable in the case of grains which are the last crop in the cycle.

Spaces between blocks and treatments also make work with the ox-team difficult. This means that the participating farmer must prepare the land with a pick which requires more time and effort and more personnel. The use of short furrows requires reloading the "quipi" that the planter uses to carry the seed he is placing in the ground, many times.

As planting is done as a team, the group must work in close coordination. The ox-team goes ahead opening the furrow followed by the person who places the seed in the ground and then by the one who distributes the fertilizer. If any of the three takes longer at his/her task than is allotted, the work of the rest is disrupted. For this reason the distribution of small amounts of seed of any variety or treatment requires that the sower reload the "quipi" which takes additional time. A similar situation is true in fertilizer treatments. The problem here is that the person responsible must modify the quantities which he/she is distributing in short distances running the risk of altering at random the amounts which are applied. This is especially true because the distribution is done using hand measurements.

In the case of experiments for parasite control with animals, it was found that any family herd was too small to carry out an entire experiment. In addition, the farmer was unwilling to treat only selected members of the herd. When experiments were done on endoparasites, the participating farmer was unwilling to sell an animal for sacrifice so that the appropriate laboratory analyses could be carried out.

Due to these problems and incorporating the suggestions of the farmers we have made adjustments in the experimental designs which permit control and measurement at the same time that the work processes of planting and harvest and of animal management may be carried out normally.

Alternatives

1. Separation of Blocks and Treatments using Tubers

In order to avoid the uncultivated spaces between blocks and treatments an attempt was made to plant tarhui (an andean legume) as a divider. At harvest however, it was observed that the ripening of the potatoes and tarhui did not coincide and the ox-team killed the tarhui when loosening the potatoes. During the second year the tarhui was substituted with mashua (an Andean tuber), often planted in association with potatoes. This process consisted in planting an entire "quipi" of potatoes of the variety or treatment desired in the prepared furrows and then placing 3 or 4 tubers of mashua before continuing the next treatment. This system avoids time loss at planting and permits a simultaneous harvest. In subsequent experiments it was found that five tubers of mashua is the minimum which guarantees that the treatments will not be mixed when the ox-team loosens the tubers at harvest (figure 1). The only special care that must be taken is to note carefully the direction in which the planting team has worked (up one furrow and down the next) so that the identification of blocks and treatments is not confused.

2. Planting of Tubers in Complete Furrows

A second alternative for avoiding uncultivated land is to plant the tubers of each treatment in a series of complete rows. If this is done, the number of rows must coincide with the quantity of tubers in a "quipi". For potatoes this implies a minimum area of 20 square meters and requires a larger quantity of seed for each treatment and block than for alternative 1 (figure 2). This method can also be used for experiments with maize, peas, quinua and tarhui.

3. Distribution of Grain Plots

In order to avoid the problem of uncultivated land in plots of barley, wheat and oats which are planted by the broadcast method, the local form of sowing was taken into account. MELGAS of 3 to 4 meters wide are used to guarantee uniform seed density. Although the MELGAS are contiguous, the ox-team marks them with a shallow furrow and the sower limits his distribution pattern to this width. Blocks and treatments are planted in complete MELGAS and the evaluation is done in the central parts to avoid any mixing at the edges (Figure 3).

4. Use of Different Family Herds as Blocks and Treatments

To alleviate the problems mentioned in animal health experiments, several modifications were made. Family herds were used for each block or treatment. Care was taken to choose herds grazed in similar areas of the communal range during the same number of hours daily. Each herd however is kept in a different corral at night. Here, the entire herd (average 25 sheep) was administered the

appropriate treatment and the animals of similar ages (50 percent of the total) were sampled at random (figure 4). In the cases where sacrifice was imperative the chosen animals were replaced by younger ones of the same sex into mutual agreement with the farmer.

The Farmers' Evaluation Criteria

The farmers' evaluation criteria may be very different from those used generally under experimental station conditions. In addition to yield, potatoes are evaluated for their color, resistance to pests, plagues, freezing and hail, capacity for long-term storage and for taste and texture when cooked. Grains are evaluated not only for size and color (larger and whiter ones bring higher prices), but for the palatability of the residues as animal fodder.

Sheep size is important as one animal is the smallest unit of convertible cash which must be spent at one time. For this reason a large animal is not necessarily the most advantageous. Different colors and qualities of wool are used for different types of weaving making uniformity of quality less important. Resistance to parasites and infections makes rustic breeds more valuable under the less than optimum range conditions which the small farmer must contend with.

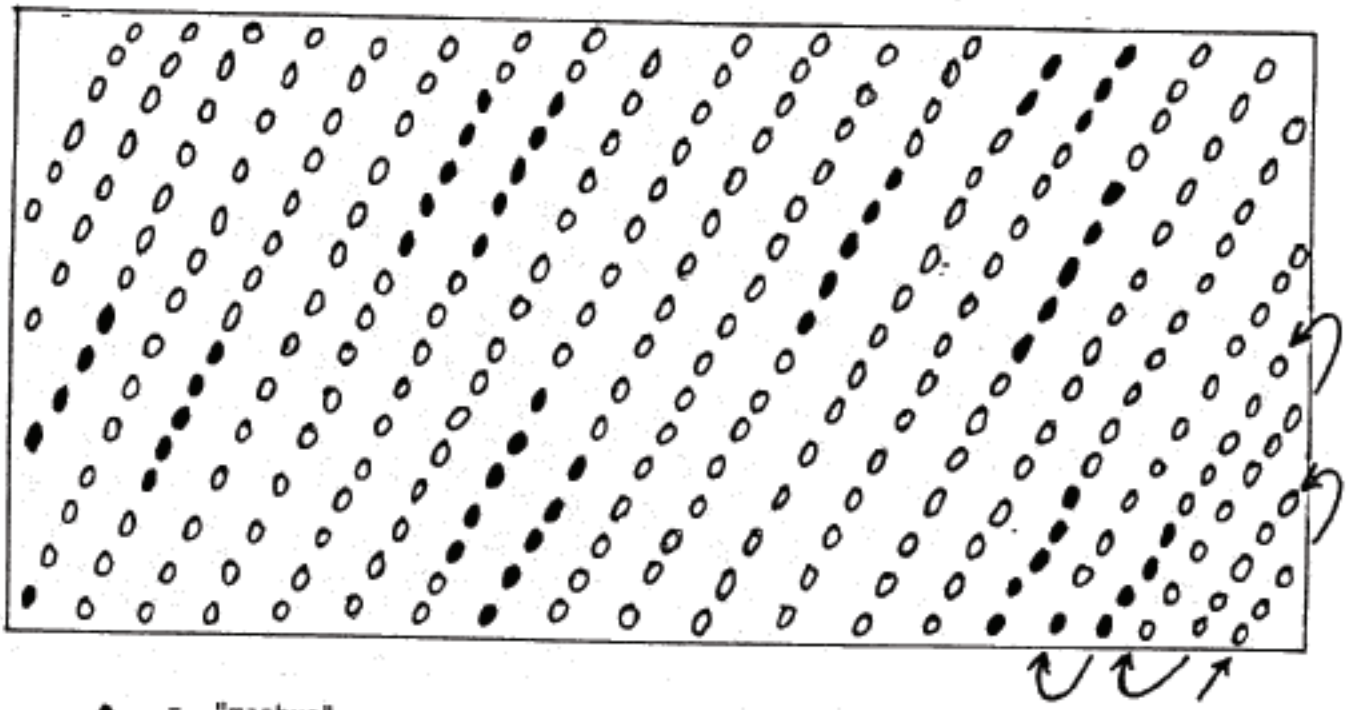
In general we have been able to identify five basic criteria for the evaluation of technology modifications.

1. Rusticity
2. Minimum requirements of external inputs
3. Multiple use value
4. Storage capacity and adequacy of disposable units
5. Adaptability (time, space and quantity) of labor requirements.

Acknowledgements

[1]This research is being carried out as part of the Title XII Small Ruminant Collaborative Research Support Program under Grant No. AID/DSAN/XII-G-0049 and AID/DAN/1328-G-SS-4093-00 in collaboration with the Peruvian National Institute for Agricultural Research and Extension. Additional support was provided by the University of Missouri. The names of the authors are listed in alphabetical order.

FIG. 1: Separation of blocks and treatments using tubers



● = "mashua"

○ = potato

FIG. 2: Planting of tubers in complete furrows.

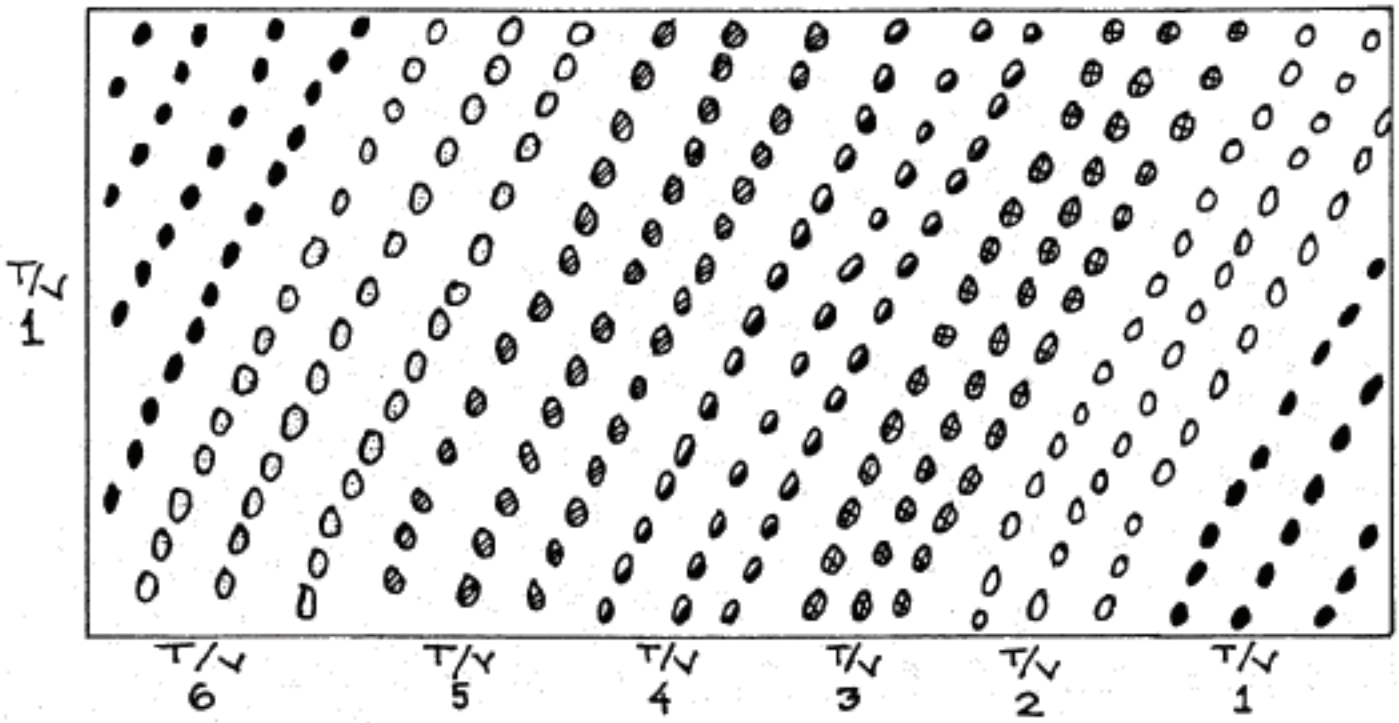


FIG. 3: Distribution of g rain plots.

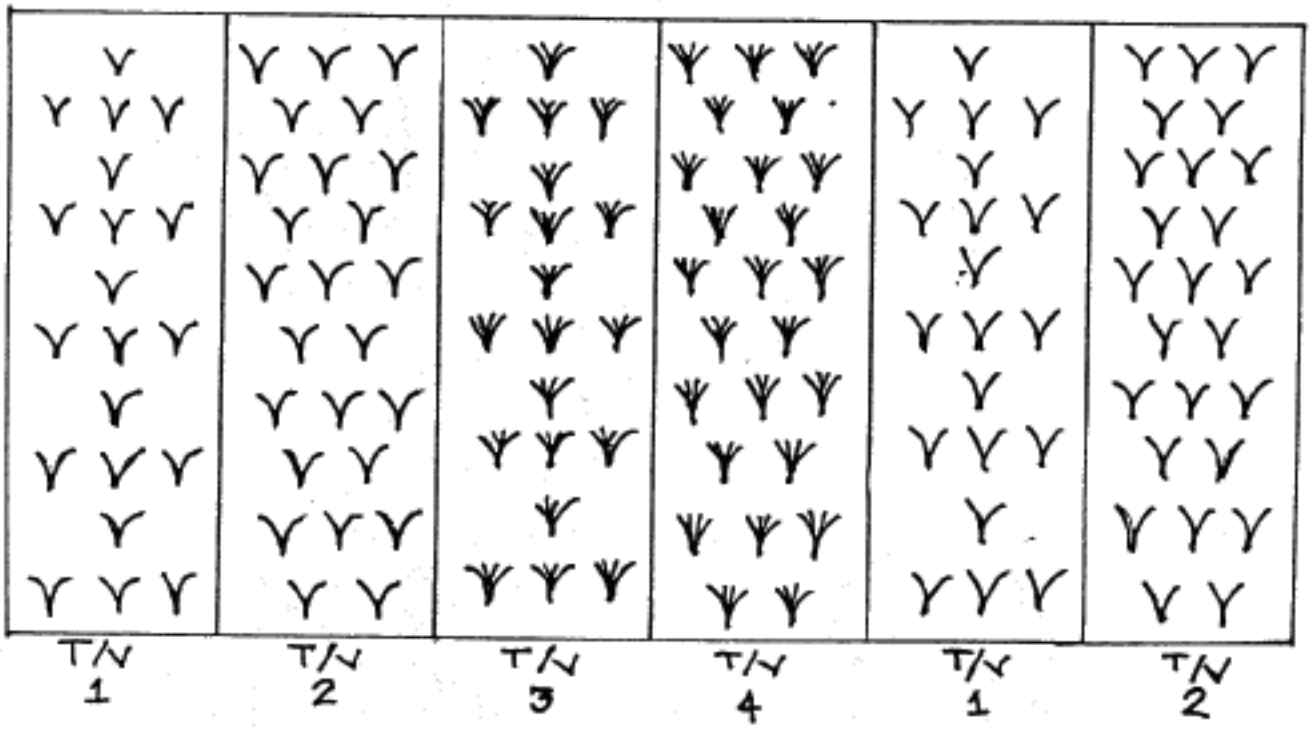
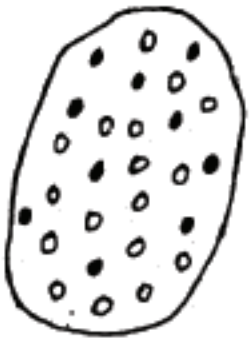


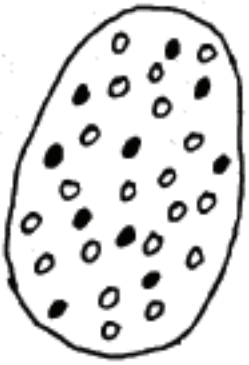
FIG. 4: Blocks and treatments using family herds.

FAM.1



FAM.2

FAM.3



FAM.4

Agro-Pastoral Production Systems, in Peruvian Peasant Communities[1]

Keith Jamtgaard

Introduction

Although the settings and goals for particular development projects will in most instances be determined by national policy-makers using political-economic priorities, it is still sometimes difficult to know where to begin even after national priorities have been set. Given the large variation in the organization of producers and their production systems sometimes present in the areas of developing countries where farming systems research (FSR) is being considered, developing a means for summarizing this often substantial variation is an important step to be taken prior to beginning field work (Bernsten et al, 1984).

Peru is a good example of this kind of variation, with an enormous amount of environmental as well as organizational diversity in production. Small independent producers farm irrigated river basins in the coastal desert while only a few hours away communities of peasants farm at over 3,600 meters of altitude in the high Andes. Medium sized farmers located in the Amazon basin further to the east engage in a thoroughly different tropical agriculture, and large cooperative enterprises created by the agrarian reform of the 1968-1980 period are also operating throughout the major agro-ecological zones of the country.

One of the problems that surfaces even for commodity oriented research programs such as the Small Ruminant CRSP in Peru is that of the question of which production organization as well as which production system should be the target group for the project. To illustrate, suppose that improving sheep production among Peruvian producers is a priority, as was the case for the Small Ruminant CRSP in Peru. Even if we confine ourselves to those producers normally considered "small scale", we still encounter a wide distribution of types of ownership. One 1977 estimate was that about 52 percent of the sheep were held by peasant communities, another 15 percent were owned by cooperative institutions created by the agrarian reform, and the remaining 33 percent held by independent producers.[2]

Each of these forms of production represents a fundamentally distinct type of production organization with a different scale of production. Even though the three forms often coexist within the same agro-ecological zones, fundamentally different improvement strategies must be devised for each of them due to their different relations of production, and relationships with the state. For instance, the cooperative sector consists primarily of large haciendas expropriated by the state, and retains a fairly close association with the state. Private producers are seen as being among the most productive farmers, and have been the beneficiaries of many of the country's recent efforts at increasing agricultural productivity. The members of the country's

peasant communities are the most numerous of the rural sector, and arguably own the largest share of production of many livestock and crop species. At the same time, historically they have tended to be the most disfavored by development efforts, agrarian policy-makers, distributors of improved technologies, and providers of credit services. Therefore, it was decided that the SR-CRSP would pay particular attention to ways of improving the small ruminant production of these producers.

Still, even having narrowed the population down to this group, one is faced with the question of where to begin. One question which remained was that of the relationship of the animal population, particularly sheep and domestic camelids (alpaca & llama), to agricultural resources, for the Peruvian peasantry. In other words, are more of these livestock held by communities which also have important agricultural holdings (agro-pastoral communities), or do communities which depend principally upon livestock for their livelihoods (pastoral communities) occupy the dominant position for these species? Information on this topic is important for programs considering improving the output from the livestock sectors of Peruvian peasant communities, since it is well accepted that the management of animals in a context where cultivation also occurs places quite different constraints upon producers from a production system where only livestock are raised (Vincze, 1980; Orlove, 1977). An extension of this question would then also concern the distribution of crop resources between agro-pastoral and the more purely agricultural communities.

While Andean livestock communities are usually found at altitudes above 4,000 meters, typical agro-pastoral communities tend to be found at "lower" altitudes, between 3,500 and 4,000 meters. Since households are intensively engaged in two very different productive activities, their labor needs and availability can also be very different from those involved only in livestock or crop production. Women are often found to be those with primary responsibility for livestock in agro-pastoral communities, while men tend to take the lead with crops. Management of the agricultural sectors of such communities also varies from that of yet another type of production system, that of purely agricultural communities.

Through an agreement with the Peruvian government's Dirección de Comunidades Campesinas y Nativas (DCCN), data collected in 1977 as part of a study of 2716[3] of Peru's peasant communities (DCCN, 1980) were made available for the purposes of considering this issue. This is a unique data source, since no other study has managed to conduct a systematic survey of such a large number of these rural Andean institutions. It was originally conducted as an evaluation of the effects of the agrarian reform which took place during the late 1960's through mid 1970's. During this reform, most of the privately held haciendas in Peru were taken by the central government, cooperative enterprises were formed from them, and in some cases land was distributed to neighboring peasant communities. Among the information gathered in the 1977 study were a number of important indicators of crop and livestock production in the communities, including the cultivated areas and herd populations of most of the important crop and livestock species. The remainder of this paper reviews a set of procedures which permit the development of a typology of different production systems, which can then in turn help gauge the relative importance of very different kinds of production systems.

Peruvian Peasant Communities

About half of Peru's rural population are members of legally recognized peasant communities, scattered throughout the slopes and valleys of the Andes. As a unit of rural social organization, many peasant communities pre-date the arrival of the Spanish in the sixteenth century, and some probably have their origins in the remote past. The Spanish conquest and subsequent independence led to a process of official recognition of these rural institutions, based along the lines of the Spanish comun (Arguedas, 1968).

Peasant communities are vitally important in the national agricultural picture, since they are owners of over half of Peru's sheep and other livestock populations[4], control as much as 90 percent of the hectarage of the key potato crop, and are dominant in other important crops as well (DCCN, 1980). Those living in peasant communities differ from private farmers in that most of their pasturelands are held in common, and many of the production decisions are made in community assemblies. They differ from many production cooperatives in that important segments of the production process still remain under household control. Peasant communities as agricultural producers are characterized by this mixture of collective rules and individual rights and obligations, which may extend from the designation and management of communal pastures to agreements concerning the sequence of crop rotation and duration of fallow for sectorial fallowing systems. Although each household is assigned its own plots and owns its animals, much of the work usually entails the coordination of schedules for several households, and occasionally the entire community is involved.

Apart from similarities or differences in the organization of production, there is also a strong cultural and political significance to the Andean peasant community. It is in practical terms the lowest unit of political organization in rural mountain areas, and is additionally the lowest level at which individuals express a unique cultural identity. Positions with fixed terms of office exist for both political and cultural roles within the community, with prestige closely linked to the fulfillment of these offices.

Two problems often occur for those wishing to generalize about farming and livestock activities in the Peruvian peasant communities. Both result from the tremendous environmental variation that exists from one end of the country to the other, or even within a single community from its highland pasture of over 4000 meters, to the valley floor 1000 meters below. For the researcher interested in the production occurring in a single community or region, this variation deters one from having even the crudest sense of location of that community or region with respect to basic production parameters from the larger population of Peruvian peasant communities. For those interested in designing programs which could have applicability for some subset of Peru's peasant communities, one is left unable to distinguish even the most general production differences among communities. The tendency has been to therefore view the Andean peasant communities as an impossibly diverse population, and thus confine observations to individual communities, small regions, or at the other extreme to a monolithic population of "comunidades campesinas".

A Production Systems Typology

One concept that provides a different perspective of the problem of widely varying ecologies is that, to a certain extent, the production of specific crops or livestock species imposes similar constraints upon the producer regardless of the micro-ecological niche in which they may be located. For example, the cultivation of barley will always require a considerable initial labor investment to prepare a field, followed by planting, and so on until harvest. There will be considerable periods of time during which little can be done other than to allow the processes of nature to ripen the crop. This contrasts somewhat with livestock in that labor must be expended on a more nearly constant basis in herding, although there do exist certain periods in which labor demands also increase, such as during lambing or shearing as in the case of sheep. Following this pattern of thought, what then becomes critical to understand is the particular array of plants and animals being utilized in a given context, as well as the relative importance of these products for the production system.

Having said this, inherent in the use of production variables remains a crude indicator of the ecological resources present in a community by virtue of the fact that certain ecological (mostly vertical) boundaries exist for some of the crops and animals commonly produced in the Andes (Murra, 1972; Flores Ochoa, 1984; Dollfus, 1981). For instance maize is unlikely to be found at altitudes much above 3600 meters (Gade, 1975); crops such as sugar cane, and rice occur mainly at low altitudes; while the Andean camelids (in particular the alpaca) are often found at altitudes above 4,100 meters, and it is commonly believed that they do not survive well at lower altitudes due to disease problems (Custred, 1977).

This paper focuses on a series of procedures which permit the development of a typology of different production systems found in the population, allowing for the grouping of communities with roughly similar indicators of crop and livestock production. The problem reverts to the unmanageable if one considers all the dimensions upon which- it is meaningful, and even important to try to characterize this population.[5] The goal of this undertaking was to develop a typology which could help reduce somewhat the immense variability in peasant community production systems into a somewhat more manageable series of categories. It was hoped that categories representing agro-pastoral, livestock, and agricultural communities would emerge from the analysis, permitting some conclusions be drawn regarding the relative importance of these different kinds of communities for animal and crop production.

Obviously any response to the question of the relative importance of certain kinds of production systems depends a great deal upon where one draws the complex boundaries between agro-pastoral and pastoral production systems. Much of the discussion concerning methods for constructing typologies concerns the degree to which one should specify the criteria to be used for drawing the limits between categories, or employ algorithms such as cluster analysis. One can argue that both strategies utilize a combination of imposing structure upon the data along with revealing structures within the data. However, given the difficulty in specifying adequate boundaries between categories for this problem, it was decided to use cluster analysis to help with the task of typology construction.

It is not maintained that the categories developed here are represent the "true" characterization of peasant community production systems, or in other words that this technique has been able to reveal the "correct" set of underlying categories actually found in the population. Rather, the goal here was one of reduction: to develop a typology which could be useful in summarizing the large amount of variation in Peruvian peasant community production systems through developing a relatively small number of categories representing some of the principal differences found in production systems. As Everitt (1980) has said:

> [I]n many fields the research worker is faced with a great bulk of observations which are quite intractable unless classified into manageable groups, which in some sense can be treated as units. Cluster techniques can be used to perform this data reduction, reducing the information of the whole set of say N individuals to information about say G groups (where hopefully 6 is very much smaller than N). In this way it may be possible to give a more concise and understandable account of the observations under consideration. In other words simplification with minimal loss of information is sought (Everitt, 1980, p. 4).

The categories finally selected were chosen over dozens of other alternatives examined, but as is the case with many statistical techniques such as cluster analysis, objective criteria cannot be offered as "proof" of superiority of one typology over any other. The final decision as to the appropriateness of a given solution remains a subjective one.

Procedures Followed

The basic method followed was: 1) selection of the variables to be included in the analysis; 2) data preparation, first through a logarithmic transformation and subsequently by standardizing the variables; 3) principal factor analysis was employed to assist in reducing the number of crop and animal variables to a smaller number of frequently occurring combinations of these; and 4) the scores from this procedure were submitted to a cluster analysis, with the objective of constructing categories of the various frequently occurring combinations of production systems.[6]

Many of the variables considered for inclusion in the analysis had highly skewed distributions. In the case of sheep, while 97 percent of the peasant communities had some sheep, just three communities accounted for over 5 percent of the total of 7,807,851 sheep held by Peruvian peasant communities. The median number of sheep held by a community was 1,000 while the mean was 2,875, also indicating a highly skewed distribution. This same kind of problem was reflected for nearly all of the production variables considered. Although some extreme outliers could be removed, and in fact some eventually were, initial attempts at clustering suggested that a relatively small proportion of communities were exerting undue influence on the clustering results. The exact proportion of communities with high values varied depending on the crops or livestock species considered, but a fair estimate would be around 10 percent for each crop or specie. Considering that the communities exhibiting extreme values usually differed depending upon the type

of product being examined, there seemed to be too many communities involved to simply remove them from the analysis.

A solution to this problem was found by using a logarithmic transformation of the variables of interest. Everitt (1980) suggests that in cluster analysis, due to the "arbitrariness involved in scaling and combining different variables there is rarely any justification for using the particular values rather than values obtained from some monotonie transformation; for example, their logarithms or square roots." Since the variables were still all of widely differing scales, it was decided to standardize them to a mean of zero and standaro deviation of 1 prior to factor analysis. This is a fairly routine step prior to factor analysis and is not consequential for the analysis itself (Kim and Mueller, 1978). Standardization is also useful for scoring variables for later use in the cluster analysis step, since the Euclidean D dissimilarity measure was selected (Everitt, 1980, p. 57).

The next step involved excluding outlier communities as well as communities with insufficient information from the analysis. Since there was very little missing information indicated, eight communities which registered zero (hectares or livestock) on each of the variables of interest were excluded prior to the logarithmic transformation. To identify outliers still occurring after the logarithmic transformation, prior to conducting the final series of cluster analyses, a K-means cluster analysis was performed with 50 clusters specified. Those clusters consisting of only one observation were then removed from the analysis. Four communities were eliminated in this manner.

It was decided to do a factor analysis of the main crop and livestock variables prior to clustering for two reasons. First of all, some crops or livestock, or combinations of crop and livestock species may occur together so frequently that it may be possible to consider them as one "complex" or factor. A reduction in the number of variables would make cluster analysis both more efficient in terms of computing resources, and easier to interpret than would be possible dealing with all of the original variables. Another reason for this step was to check for the presence of agricultural products which may tend to be present in association with so many other products that they are of little use as distinguishes of different production systems. Therefore, the factor analysis step was important for revealing which variables would be the best and worst indicators of differences between production systems.

This analysis was undertaken with the production indicators available in the DCCN study. A number of important traditional and subsistence oriented crops[7] were not included in the main study effort, and may have been useful in more carefully distinguishing the production systems. Still, it is felt that the agricultural commodities that were included in the study were more than adequate for the purposes described here.

The factor analysis stage became kind of an iterative procedure, during the course of which many different solutions were examined. It would not be possible to discuss each of these here, however it was possible to eliminate a number of variables rather quickly. Variables representing the number of swine, cattle, and hectares of potatoes were dropped due to their being found

in many different combinations of production systems, and therefore were not useful for distinguishing any one system. Variables designating the number of hectares of rice and tobacco were also dropped, but for the opposite reason of rarely being present with any other production indicators, this may suggest that they are more important as representing monocultural community production systems. Four factors were chosen, and they consisted of the combinations of variables shown in table 1.

A community's value for each of these measures is simply an indication of the relative importance of that production area using the population of communities studied as a reference point. The notion of scale of production is also incorporated in the measures, so that increasing values indicate increasingly greater commitments to the production activities which make up he factor. At this stage there is no indication of the relative importance of one area of production over another for a given community. That is, the fact that a community has a high score on the "Livestock" index does not mean that it cannot have an even higher score in the "Sierran Agriculture" index.

Given the strong relationship in the Andes between vertical zone and production activity, labels were tentatively assigned to the four factors based on a judgment of the type of vertical production zone thought to be best represented by the variables emerging from the factor analysis. For example, the factor labeled Sierran Agriculture was assigned this title due to its being characterized by the three principal (non-potato) crops which may be produced at altitudes above 3,300 meters and which share the characteristic of being frequently produced in the absence of irrigation.

Although most of the 2716 officially recognized peasant communities are found in the mountainous Andean region of Peru, some of the communities are found in the coastal region, as well as the lower altitudes of the Eastern slope of the Andes.[8] The "Lowland Agriculture" measure represents three areas of production frequently found at lower altitudes: coffee, sugar, and orange production. A high score is simply an indication of a substantial commitment to the production of these crops, relative to the population of peasant communities.

One of the more difficult measures to label was that of the "Intermontane Valley" index. One of the key distinctions between peasant communities was seen to be the degree to which they had access to low altitude irrigated fields suitable for maize, and apparently related to this was the presence of alfalfa and goat production. It should be emphasized that this does not mean that there are numerous communities in Peru where the diets of goats are being supplemented with alfalfa, but simply that it appears that these three activities are occurring together with sufficient frequency to merit considering them together rather than separately. As was mentioned above,
other production activities such as cattle, potatoes, and swine were left out of this analysis due to their continued presence under highly variable conditions.

Finally, the Livestock index was again associated with a particular latitudinal production zone, which was that of the higher altitude puna of 4000 meters and above. This is due primarily to the strong extensive grazing orientation for most mountain communities, and the prominent role of mountain

rangelands as the primary feed source for sheep, alpaca, llama, horses and burros. This is not to say that large herds of all of these cannot be or are not maintained on cultivated forages at lower altitudes, but simply that the production of these three occurred with enough frequency to be considered together.

What follows then is an interpretation which makes use of these four measures to generalize about the degree of involvement of the Peruvian peasant communities included in this study in different areas of production. In a sense, the typology which emerges from the cluster analysis is a summary of the different combinations of access to these four production zones found across all of the peasant communities included in the study.

Cluster Analysis

From a technical perspective, one of the more challenging features of this undertaking is the large number of observations to be classified. Cluster analysis is not a single technique, but rather a family of algorithms which share the goal of grouping observations according to criteria of similarity or difference. However the number of alternative procedures rapidly shrinks when one introduces the constraint of a large number of observations to be classified. Therefore, a non-hierarchical method was chosen, that of the k-means approach (MacQueen, 1967) using Anderberg's (1973) centroid sorting method.[9]

One of the major uncertainties with this (or any other) variety of cluster analysis is the decision on how many groups to accept. This decision is equivalent to resolving how many categories will be present in the typology, and must therefore be carefully considered. After testing a wide range of possibilities, including solutions ranging between four and twenty groups, it was decided to accept the fourteen group solution (see table 2). Those solutions with fewer groups seemed to mask important differences among production systems, while those with more groups seemed to focus on different scales of production rather than on new combinations of production systems.

The fourteen categories of production systems that emerge from the cluster analysis do still bear enough similar features to justify utilizing them as "building blocks" for making higher level generalizations about production systems, and one such interpretation of the categories is offered through the labels used in table 2.

Perhaps the most distinctive characteristic of this solution, and of the alternative solutions examined as well, is that of the relatively large number of different categories produced for lowland community production systems relative to the small number of communities classified as Lowland communities. Of the fourteen groups identified by the algorithm, six had as their most distinctive feature high scores on the lowland production measure. This attribute is interpreted neither as an important finding, nor as a problem for understanding the other categories, but simply as perhaps a consequence of having included an entire factor solely for the purpose of distinguishing such a small number of communities.

Focusing then on the numerically more important highland communities, a number of observations should be made regarding the remaining eight cluster categories. Clusters groups seven, eight, and nine were considered "Agro-Pastoral" in that, when compared to the other categories, they seemed to have important activities in both the agricultural and livestock areas. Communities located in cluster category seven had major production commitments in both the Livestock and Intermontane Valley production areas, and to a lesser degree to the Sierran Agriculture products. This contrasts moderately with the strong emphasis on Sierran Agriculture for those communities in the eighth category, their diminished involvement with livestock production, and non-existent participation with the Intermontane Valley production areas. The ninth category clearly represents the very largest highland peasant communities with heavy involvements in all three highland production zones.

Two categories were placed under the Livestock heading. The first (cluster number ten) is a rather clear-cut case of communities which have significant livestock activities, and little else as evaluated here. The second livestock category (cluster number eleven) is more complicated. The communities located in this group were considered livestock producers simply because they appeared to have more involvement in this area than any other. It is important to note though that size of production is a consideration here, and that the communities grouped in this category are primarily small highland communities engaging more in livestock production than in any of the other production areas examined here.

Finally, the three remaining clusters (twelve, thirteen, and fourteen) were seen as being primarily agricultural due to their low scores on the Livestock index. There were significant variations here as well, with cluster group twelve representing communities with large amounts of production taking place in the Intermontane Valley area, and with little else. Those in group thirteen had similar activities in the valley zone, but complemented with even larger commitments to the Sierran Agricultural products. Lastly, those communities found in the fourteenth cluster grouping were similar to those of group eleven in that they had low scores on all of the production measures. After discounting the lowland agricultural score by virtue of the fact that it is already at its minimum, the next highest score lies in the area of Intermontane Valley measure. These might then best be described as very small communities, with some tendency toward production emphasis in maize, alfalfa, and goats.

Conclusion

Let us return at this point to the original question of the distribution of livestock and crop resources across different types of production systems. By reconstructing some of the original, unaltered, production indicators and examining their values for the headings just described above (table 3) , some conclusions may be made regarding this issue. Once again, these conclusions refer only to the distribution of productive resources across legally recognized peasant communities, and not to the national production picture, although it is felt that these kinds of findings could be important for those

who wish to focus on particular aspects of the productive capacity of peasant communities.

Livestock communities are of primary importance when it comes to camelid production with nearly three-fourths of the population of these species being held by such communities. The remaining quarter of the camelid population are held by mixed agro-pastoral producing communities. By contrast, agro-pastoral communities are of equal importance to livestock producing communities in sheep population, with 45 percent and 44 percent, respectively, of the herd populations belonging to these types. Cattle are more evenly distributed across different production systems, but even here, agro-pastoral communities hold a dominant position with 47 percent of the cattle herds.

Looking at the agro-pastoral communities, it is clear that they are important actors when it comes to some of the principal crop species as well. Looking at the three key crops of potatoes, maize, and barley, only in the case of maize do agricultural communities hold equal importance to the agropastoralists. Previous research indicated that agro-pastoral peasant communities differed in important ways from both agricultural and pastoral communities. In recognizing the relative importance of crop and livestock production for these communities, it was also clear that a FSR approach would be useful for examining the possibilities for livestock improvements while remaining conscious of the importance of crop production and the interactions
and conflicts between these sectors for agro-pastoral producers.

Based upon evidence from this kind of analysis, the SR-CRSP then focused its efforts at validating livestock technologies for peasant communities upon the dual character of livestock production in the Andes: livestock communities, and mixed agro-pastoral communities. Community sites were selected in two regions, a community from the department of Junin in the central sierra of Peru was chosen as a representative of agro-pastoral production, and the Department of Puno in the south, where a more pure livestock oriented community was selected. Recommendations for future livestock interventions in peruvian peasant communities build upon the experience obtained in these sites.

The procedures employed for developing the production systems typology described here could be helpful for others wishing to classify peasant production systems in very general production terms. Clearly, this represents only a first step, and more work is needed to develop homogeneous production categories. Still, the usefulness of this scheme perhaps lies not only in the typology, but also in the ability to identify communities falling into each of the categories. Sampling certain kinds of production systems from a population becomes more feasible. Even where sampling is not employed, by obtaining a small number of production parameters it becomes possible to see where a given peasant community is located with respect to the larger population.[10]

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Notes

[1]This study was carried out as part of the United States Agency for International Development Title XII Small Ruminant Collaborative Research Support Program under grant number AID/DSAN/XII-G-0049 and AID/DAN/1328-G-SS-4093-00 in collaboration with the Instituto Nacional de Investigación y Promoción Agraria. The 1977 Peruvian Peasant Community study data were made available through an agreement with the Peruvian Ministry of Agriculture's Office of Peasant and Native Communities (Dirección de Comunidades Campesinas y Nativas). The author gratefully acknowledges the contribution of the following individuals from that institution: Jose Portugal, Victoriano Caceres, Ivan Pardo-Figueroa, and Ing. Juana Jeri. Additional support was provided by the University of Missouri.

[2]While production estimates broken down by social organizational criteria are rare, these rough estimates were obtained by combining figures on livestock transferred to the associative sector toward the end of the reform period (Caballero and Alvarez, p. 37, 1980) and that owned by officially recognized peasant communities (DCCN, p. 37, 1980). The remainder was attributed independent producers.

[3]This was 99% of the legally recognized population of peasant communities at the time.

[4]Flores Ochoa (1984) points out the contradiction between the notion that peasants are usually considered the owners of more than 80 percent of the nation's alpaca herds, and official statistics such as those offered here, in which communities appear to possess closer to 45 percent. The difference between these two figures probably lies in the distinctive social organization of the department of Puno, which is the largest alpaca producing department in Peru. A substantial part of this production discrepancy may be made up by groups of peasant producers known as parcialidades, which are similar in many respects to peasant communities except for their unrecognized legal status.

[5]Apart from the present question of the distribution of the different kinds of production systems in peasant communities, it would also be desirable to classify communities according to more specific criteria regarding the range of natural resources available to the communities. In other words, to be able to discuss not just what the communities currently produce, but rather to identify where opportunities exist to expand or intensify productive capacity.

[6]Work is in progress for a more detailed description of the analysis undertaken in this paper, and will be published as part of the Technical Report Series of the Small Ruminant Collaborative Research Support Program.

[7]Although the study was quite thorough in its inclusion of most of the principal agricultural commodities, details on the more traditional varieties of Andean tubers were omitted, as were other crops such as tarwi and qaniwa.

[8]The numerous indigenous communities located in the Amazon Basin are considered comunidades nativas and were not included in this study.

[9]This method was used as implemented in version 82.3 of SAS (Statistical Analysis System).

[10]A template has been developed for use with spreadsheet programs which essentially performs this function by incorporating the key features of the procedures described here. After entering production data from a real or hypothetical observation (peasant community) one can quickly learn which of the categories of the typology most closely matches those of the observation.

Table 1. Configuration of the Four Factors Used in Subsequent Analyses.

Factor Label	Components[a]
1. Sierran Agriculture	Hectares of Barley, Wheat, and Broad Beans
2. Lowland Agriculture	Hectares of Coffee, Sugar Cane, and Orange Trees
3. Intermontane Valley	Hectares of Maize, Alfalfa, and Head of Goats
4. Livestock	Head of Sheep, Camelids, Horses, and Burros

[a]Factor scores were computed by multiplying the variable's standardized scores by 1 for each of the variables identified with the factor, and 0 for the others. They each have a mean of zero.

Table 2. Mean Scores on Four Measures for 14 Cluster Solution, Grouped by General Catergories[a].

Label	Cluster	N	Sierran Agriculture	Lowland Agriculture	Inter-Montane Valley	Livestock
Lowland	1	9	-1.95344	24.96425	1.20431	-0.18355
	2	19	-0.84408	8.91746	1.88506	0.74285
	3	38	-2.14259	3.53655	0.42143	-1.42240
	4	24	-2.09161	14.07012	1.17883	-1.03576
	5	14	-2.15002	8.65796	-0.06523	-4.73965
	6	19	2.85802	5.47319	2.63845	0.43129
		123				
Agro-Pastoral	7	273	0.58379	-0.41116	2.54995	1.98740
	8	296	2.77679	-0.43071	-1.64558	0.47271
	9	148	5.29509	-0.37591	3.51572	2.03488
		717				
Livestock	10	350	-1.82401	-0.43258	-1.70847	2.87303
	11	539	-1.12328	-0.43220	-1.82030	-0.21976
		889				
Agri-cultural	12	338	-1.52349	-0.41930	1.77389	-0.77548
	13	288	2.13457	-0.43058	1.15632	-1.21898
	14	349	-1.37510	-0.41812	-0.63908	-3.24633
		975				

[a]The fourteen categories derived from the cluster analysis have been reordered under the labels provided to reflect the interpretation given here.

Table 3. Agricultural Production Indicators by Production System Type.

Production System	Sheep Head	Sheep Pct.	Cattle Head	Cattle Pct.	Camelids Head	Camelids Pct.
Lowland	178,436	2.3	170,733	6.5	1,450	0.1
Agro-Pastoral	3,502,251	45.1	1,230,090	46.6	368,864	26.8
Livestock	3,416,596	44.0	729,207	27.6	989,428	72.0
Agricultural	659,968	8.5	507,686	19.2	15,228	1.1
Total	7,757,251	100.0	2,637,716	100.0	1,374,970	100.0

Production System	Potatoes Head	Potatoes Pct.	Maize Head	Maize Pct.	Barley Head	Barley Pct.
Lowland	8,175	2.6	34,320	15.7	1,555	1.3
Agro-Pastoral	157,792	50.4	88,794	40.6	83,882	68.0
Livestock	94,189	30.1	6,059	2.8	16,601	13.5
Agricultural	52,874	16.9	89,436	40.9	21,381	17.3
Total	313,030	100.0	218,609	100.0	123,419	100.0

RANGE-ANIMAL ECOLOGY AND BERBER AGROPASTORALISTS IN MOROCCO'S WESTERN HIGH ATLAS

Lloyd Mendes

INTRODUCTION

Range animal production development projects are falling in disfavor. In 1980, AID planners for Africa talked glowingly of transhumance and migration of herds.(1) By 1982, planners were still interested in range, but the pendulum was beginning to swing back: a few planners recommended limiting investments to the "higher potential, mixed farming areas, where annual precipitation is in excess of 1000 mm".(2) By 1985, range projects were no longer in favor. While livestock is still considered important for Africa, planners now want to focus investments on animal health and nutrition in higher rainfall, mixed farming systems. Within these systems they accept that nutritional stress is the major constraint and plan to remove that constraint with cultivated fodder from food crops and with improved, planted grasses and forages.(3) So range is out and mixed farms are in.

But Farming Systems Research is still favored by AID. This is why I present a discussion of Range Ecology at a FSR Symposium. I hope to convince FS researchers to consider the ecological complexity of the range component when analyzing farming systems, as one way to cheaply increase the productive area of mixed farms.

I do not mean to argue that range forage can complement on-farm forage; F.S. researchers are obviously aware of that complementarity. I argue instead that FS research of mixed farms should include an understanding of the local range-animal ecology. By understanding this ecology, the research team can plan to more fully enhance the complementarity of crops and livestock and of fields and rangelands.

In order to illustrate the importance of range-animal ecology, I will present a case from Morocco's High Atlas Mountains. The mixed farming system here is characterized by a small, arable land surface and much larger, non-arable range area. Berbers in this region cannot rely solely on the limited, arable land base for their needs. As a partial solution, they raise livestock that exploit the surrounding ranges in a production system adapted to ecological constraints. This animal production system requires minimal, though seasonally critical, forage inputs from the small arable component of the mixed farms.

I will discuss three characteristics of mountain range-animal ecology and how Berbers in one high mountain valley adapt to this ecology. These three characteristics are ecological differentiation over a short distance, the cyclical nature of range-animal production and uncertainty of production from year to year. Adapting to this ecology, Berber shepherds exploit a wide range of ecological zones and respond flexibly to cyclical and year-to-year changes in ecological relationships. Then, following this traditional logic of adapting to range ecology, I will suggest possible improvements in livestock production in the Atlas Mountains.

I present the specific elements of animal production in the Atlas only to illustrate general, ecological principles of range-animal production. These principles can be used to enhance mixed farm development in other parts of the world where, as in the Atlas, there is much wasteland outside the arable perimeter.

SETTING

This study took place in the Imenane, a high (1600-3800m) valley, in the Rherheya watershed which drains into the Oued Tensift from the North slope of the Western High Atlas Mountains (see Figure 1A). Located about 50 Km south of Marrakech, the valley's geographic coordinates are centered at 7°50'W 31°10'N. The inhabitants, Tichlehit-speaking Berbers, are sedentary agro-pastoralists. This paper concerns small ruminant production in the upper 2/3 of the Imenane watershed where irrigated agriculture predominates over dry land cereal-culture. (4) It also concerns the Haoz Plains (200-600 m. elev.) around Marrakech, which are part of the mountain/plains complex exploited by Imenane flocks.

Agricultural production is based on a two-crop per year rotation of corn in summer and barley in winter. Permanent meadows are also sown; they are harvested for hay in summer and grazed for re-growth in winter. Besides flocks of sheep and goats, described below, most families own one or two dairy cows and a mule or donkey. Cattle and equides are fed almost exclusively from the irrigated fields or from feed imported into the Imenane.(5)

METHODS

The study, funded and directed by the Sociology component of the CRSP Small Ruminant project, used two types of data -- background data and case studies of particular households. Because of the nature of the data, only orders of magnitude are claimed to be shown.

An overview of the study area was obtained from maps, aerial photos and tax records of livestock holdings. These kinds of data sources are usually considered reasonably representative of an entire region, but of questionable accuracy. Therefore, I report this data only to one significant figure, doubting that it merits being considered as more precise.

Watershed and irrigated field surfaces were planimeterd respectively on a map and on aerial photos that had been ground-truthed in 1985.(6) These data are only meant to show orders of magnitude, and are reported only to one significant figure.

To study more specific relationships between land and livestock, I studied the livestock production of six households in the Upper Imenane. The households were selected on the basis of their having flocks and of their willingness to be interviewed. Not being statistically representative, the data in each case study were treated as a census, and analyzed only as simple percentages. Deriving insights to apply to the larger population of Imenane Valley and Western High Atlas households in areas of similar environment is therefore a subjective exercise.(7)

In mid-winter 1985, each household head was asked to recall for the previous year, and predict for the coming spring, forage and grain production

and consumption, and flock movements. Household flocks were all individually handled at the same time, while the shepherd was asked to recall parturitions and deaths within each animal "lineage" in the flock. Again, such data, based on recall, can be inaccurate. But, reported only to one significant figure, it suggests the broad lines of small ruminant production of the households studied.

MAIN ARGUMENT:

1. ARABLE LAND IS INADEQUATE TO THE CURRENT POPULATION'S NEEDS

In the Western High Atlas mountains, steep topography, poor soils and low rainfall limit arable land to narrow, irrigated valley bottoms. Typical mountain slopes are 20°-30° and are hardly stable even if undisturbed. Soils in most of the upper watershed are coarse-grained and shallow to bedrock. Even where soils are finer and deeper, rainfall is relatively low: 370 mm/year over the past 8 years.(8) Though some dryland barley is cultivated, these conditions restrict most agriculture to the irrigated 2% of the watershed surface.

Agriculture based soley on this small irrigated area cannot meet the current human population's needs. Population density is high in the region: 35 persons per cultivated hectare (9) or roughly 0.6 hectare of irrigated land per taxed household in the Imenane.(l0)

Because of the importance of grain to the diet and economy of Berber households, the insufficiency of grain production can indicate the shortage of arable land relative to population density in the Imenane. The Berber inhabitants have been known for centuries to be dependent on the adjacent Haoz Plains around Marrakech for grain, their food staple.(11) Traditionally, the mountain's strategy has been to import a large part of its grain needs bought with income from the export of labor and livestock to the Plains.(12)

This strategy can still be observed in the Western High Atlas. Of 5 families studied in the Imenane Valley in 1985, most produced between 10 and 20% of their estimated grain needs in the agricultural year of 1984-85. Of the 13,000 Kg grain consumed in the five homes over the same year, only 2000 Kg, or about 20%, were produced locally. The rest was bought from the Plains, much of it with cash earned from the sale of sheep and goats.

Atlas Berbers keep much livestock in relation to the small arable land surface. The 284 households of the Upper Imenane owned 9834 small ruminants in 1979 or, on average, 35 head per household. They also owned 625 cattle, or about 2 head per household. Calculated on the basis of 200 hectares of irrigated land in the valley, this equals about 3 cattle and 50 small ruminants per irrigated hectare. In addition, many families keep a mule or donkey. It is impossible for all of these animals to derive the bulk of their nutrition from the small, irrigated land area.

In fact, flocks in the W.H.A. are shepherded most of the year on native ranges. Some animals are allowed to graze the small, irrigated terraces, but they represent a small proportion of each flock and graze the terraces only in winter, as shown in Table 1. In 1983-84 most of the flock derived its

nutrition year-round from native ranges. All of the flock depended on range forage for at least half and more commonly for 3/4 of the year.

2.PROBLEMS AND OPPORTUNITIES OF RANGE-ANIMAL ECOLOGY

But exploiting mountain rangelands involves more than simply herding animals outside the arable perimeter and hoping they will find forage. Range-animal production presents special problems and opportunities. The problems can be avoided and the opportunities exploited only by understanding several characteristics of range-animal ecology. In the Imenane, these are: ecological differentiation over a short distance, the cyclical nature of range-animal production and the uncertainty of production from year to year.

2.1. ECOLOGICAL DIFFERENTIATION OVER A SHORT DISTANCE

Rangelands in the area exploited by Imenane flocks — from the peak of Jbel Aksoual (3842m) to 50 km away on the Haoz Plains around Marrakech (470m), -- vary greatly in ecology over a short distance. This ecological variation along the elevation axis of the mountain/plains complex is called vertical ecology. Temperature decreases with elevation, with yearly averages of 17 Degrees C at one 1000m elevation station and 13 Degrees C at a higher, 2100 m. elevation station.(14)

Precipitation increases with elevation, due to the orographic effect of the Atlas mountains which force moist air coming from the Atlantic to rise. This is shown by the average yearly precipitation of four stations in the Rherheya watershed, illustrated in Graph 1.

These differences in temperature and in precipitation, coupled with other factors such as geologic formations, express themselves in the mountains in different vegetation zones. The low-lying, warm, dry plains are sparsely covered with desert shrubs and with annual herbs and grasses springing up only for a short time after the winter rains. The highest elevations above 2400-2500m are alpine zones, dominated-by low spinney shrubs and interspersed with low, sparse, annual plants during the short, snow-free growing season. An intermediate zone, at around 1600--2400m, is dominated by forest -- Oak at the lower elevations and Juniper at the higher elevations.(15)

The point I hope to make here is not just of vertical ecology, which is specific to mountain ranges. Rather it is of the general characteristic of ecological differentiation within short distances. In the Atlas mountains, this is expressed as vertical ecology; in the Sahel as decreasing rainfall from south to north or as desert versus adjacent river delta. In the cases mentioned, the juxtaposed ecological zones have alternate seasons of environmental stress. This juxtaposition presents opportunities to herds that can move to avoid stressful locations. Berber shepherds exploit these opportunities by moving their flocks over the entire vertical axis of the mountain/plains complex.

Even within the same narrow band of elevation where the ecology is generally similar --e.g. in the forest or alpine zone —there are differences in micro-climate. Southerly and westerly facing mountain slopes are warmer than northerly or easterly facing slopes, though they are only several hundred meters apart. Average temperatures, in turn, affect forage availability over

the year: south-facing slopes are snow-free in winter but droughty in summer, with the opposite true for north-facing slopes. Upper Imenane shepherds exploit micro-climatic differences in the mountains by herding flocks on north-facing slopes in summer, saving the south-facing slope ranges for winter.

2.2 CYCLICAL NATURE OF PRODUCTION

Another characteristic of range ecology is the cyclical nature of range-animal production. Two kinds of cycles occur — one climatic and seasonal and therefore yearly in length, and the other animal-reproductive and less than yearly in length.

2.2.1 SEASONAL CYCLES:

The climate on the north side of the mountains is Mediterranean, with winter precipitation and summer drought. Depending on the temperature regime at different elevations, forage grows mostly in winter (on the Plains) or in spring and early summer (in the mountains). It declines in availability thereafter as it is grazed. Coupled with the difference in elevation and in temperature between mountains and plains, this results in different cycles of forage availability.

The desertic plains of the Haoz, dry in summer, provide succulent annual growth in late winter.(16) Above the tree line, where deep snow prevents winter grazing(17) shrubs and annual plants provide succulent forage late into summer. The middle elevation Oak and Juniper forests provide a year-round, if low quality, supply of browse to goats and of emergency feed that can be cut and hauled to temporarily snowbound sheep and goats in winter.

Shepherds adapt to these major seasonal changes in forage availability along the axis of vertical ecology by transhuming: they move their flocks in a regular seasonal pattern up and down the mountain/plains complex. When shepherding their flocks on the mountains, they also exploit the smaller differences in microclimate, herding flocks on the cooler, north-facing slopes in summer and on the warmer south-facing slopes in winter. The pattern of one household in the high altitude village (2200m) of Tachdirt illustrates this seasonal flexibility (see Figures 1 and 2):

Season Flock	Grazing Location
Early Summer	North-aspect mountain above tree-line; flocks based one hour from village (2200m) (Fig. 2)
Late Summer	High mountain transhumance to grazing reserve above tree-line; flocks based three hours from village (2600m) (Fig. 2)
First Snowfall	South-aspect mountain grazing reserve, above tree-line; flocks based in village (2200m) (Fig. 2)
Late Winter	Reverse transhumance to Haoz Plains (200-600m) in years of adequate winter precipitation; flocks based one week from village. (Fig. 1)

However, even in one major ecological zone such as the mountains, forage availability varies, declining over the winter. Bourbouze observed goat diets in a forested part of the Central High Atlas Mountains. He found there that while dry matter intake remained constant over winter, energy intake declined between October and April.(18) We can assume that forage intake and energy intake are worse for sheep, which do not browse as readily as goats. Forage availability and energy intake for both species are very probably much worse in the alpine zone, where the browse provided by forest is unavailable.

One cultural adaptation to the decline in forage availability is the use of range reserves. Communal ranges are closed to grazing at particular times of the year, in order to save forage for other seasons. The deferments may be policed by religious or legal sanctions. Flocks from the village illustrated above use two such deferred, communal ranges. One is the late summer range , or agdal, of Oukaimeden; the other is the first snowfall range (azimz) near the village(See Figure 2). These communal institutions defer the use of range forage from summer, when forage is abundant, until fall and early winter when it is in short supply.

Another seasonal cycle affecting livestock production is the occurrence of diseases. Shepherds observe sudden deaths in spring among sheep that change diet quickly from dry forage on the Haoz Plains to succulent forage in the mountains. The symptoms are diagnosed by a local veterinary technician as enterotoxaemia.(19) Shepherds prevent the disease by avoiding sudden changes in forage quality. They leave the Haoz Plains early in spring before the range plants have reached senescence, and they walk their flocks gradually up to higher elevations.(20)

Liver fluke (Fasciola hepática) infestation in sheep and goats also occurs seasonally. Sheep that die in winter often show severe fluke damage when their livers are opened. Because ruminants are infested by ingesting the fluke's alternate host, a land snail found in moist meadows, it seems likely that the main infestation occurs at the late summer range (see Figure 2). Only here do small ruminants graze marshy pastures during a season warm enough to allow snail activity. The ingested larvae are known to mature in the host animal's liver in 2 to 3 months, during which they can cause considerable liver damage.(21) Berber shepherds have no effective, traditional way of treating fluke infestation.

I lack the experimental data to ascribe specific causes -- low forage availability, cold weather stress, parasitic infestations or other causes – to livestock deaths in winter. However, limited data do show that flock mortality is highest in mid winter. (See Table 2) This is when the mountains are cold and snow-bound, but before the Haoz Plains have sprouted enough new forage for flocks to transhume.

2.2.2 ANIMAL-REPRODUCTION CYCLES

The climatic cycle, and in turn the cycles of forage availability and parasitic infestations, are seasonal and recur every twelve months (though with variations that lead to uncertainty, discussed below). But the reproductive cycle of sheep and goats - which determines the timing of their forage needs - lasts only 5 months from breeding to parturition. Or we can consider it as lasting 8 months from initial breeding, through parturition and lactation,

until breeding is again possible, if the female's nutritional condition is good enough. The two cycles of different length --forage availability and animal reproduction --do not always coincide.

With sheep breeds raised in the high latitudes in which they originated, the reproductive cycle of the flock coincides with the seasons and with forage availability. In these areas of varying day length, oestrus coincides with shorter day length if the ewe is adequately fed. Thus, the ewes breed in fall and parture in spring when forage is usually adequate for lactation.(23)

But nearer to the equator, many breeds lose this characteristic of restricted seasonal breeding and breed throughout the year, depending on nutritional status. This seems to be the case in the Western High Atlas where I observed a peak of parturitions in one year due to breeding in July and August and a peak of parturitions in the next year due to breeding in May. Precipitation and therefore forage supply had changed and breeding changed with it; evidently day length was not a factor. Under these conditions, the reproductive cycle (and with it the flock's cyclical need for forage) may not always match the seasonal cycle of forage availability.

The female's nutritional condition is important at critical times during the 8-month cycle of reproduction and lactation: at breeding and during lactation. At other times, nutrition is not so critical, at least for sheep, which can draw on and later replenish body-fat reserves.(24) But ewes and does do not breed unless in good condition; this is the basis of the practice of pre-breeding supplementation, or flushing, of ewes. Lactating females must also eat adequately, or they will produce inadequate milk for their young.

The forage availability and reproductive cycles obviously coincide at the beginning: ewe and doe condition is necessarily good at breeding, or breeding could not occur. But animal condition five months later and beyond, during parturition and lactation, may or may not be good, depending on the season as well as on conditions peculiar to any one year.

Shepherds recognize several possible breeding periods for sheep, depending on the supply of forage.(See Figure 3). In an ideal year , flocks transhume in February or March and breed on the temporarily rich Haoz ranges. Ewes bred in this season will parture from July to September when the flocks are on high mountain ranges. This is considered a good parturition season by shepherds because ewes are well enough fed to lactate for the nursing lambs.

When flocks have not transhumed, but mountain ranges produce abundant spring forage, shepherds expect some breeding in May and June. Ewes bred now will parture in October and in November, when the flocks will have descended from the high alpine ranges down to village level .This is considered a bad lambing season, because the poorly fed ewes, pastured on overgrazed village ranges, cannot lactate enough for their lambs.

Finally , there are years in which flocks could not transhume to the plains in winter and breed there, nor breed in early summer in the mountains if range forage was not rich enough. In these years, shepherds expect most breeding to occur on the high mountain range in late summer. (Figure 2). The high mountain range has been protected from grazing until this time so that flocks find relatively abundant forage here even in low rainfall years. Ewes

bred early on this range will parture in January, before the flocks will have transhumed to the Plains. Lamb mortality , from cold and starvation, will be high; this is considered the worst parturition season. (See Table 3)

However, ewes bred late on this high mountain range will parture in February or March. If the flocks will not have transhumed to the Plains by this time, the parturition season will be no better than in January. The mountain forage supply and ewes' milk supply will be poor, and lamb mortality will be high. But in a year in which the flocks will have transhumed in late Winter, February and March lambs will be born on the rich ranges of the Haoz Plains. This is considered the best of all lambing seasons. Limited data confirm the shepherds' opinion: of seventeen lambs born in one flock before transhumance at the beginning of February 1985, 18% died within one month of birth. Of the 29 lambs born in the same flock over the next two weeks, after transhumance to the Haoz Plains, none had died by mid-February 1985.(25)

As noted above, transhumance between alpine and lower elevation ranges does not assure a perfectly steady supply of forage throughout the year. Partly as a result of malnutrition, mortality is high in mid-winter for adult and for newborn animals (Tables 2 & 3). When range forage is in short supply, but animal nutritional needs are highest--that is in winter--flocks are supplemented from forage produced on the limited fields of the Imenane's mixed farms.

But households lack adequate forage to supplement the entire flock throughout winter. A small percentage of the total flock uses irrigated pastures -- only 20-30% of most of flocks studied in 1983-84 (Table 1). The animals fed on irrigated pastures are lactating ewes and does, supplemented in order to reduce lamb and kid mortality during the first critical month when newborns depend on milk.

2.3 CLIMATIC UNCERTAINTY

The last characteristic of range-animal ecology that I will discuss here is familiar to agricultural scientists working in semi-arid climates: climatic uncertainty. Climatic uncertainty leads in turn to two uncertainties in range-animal production in the Western High Atlas. These are: fluctuations in forage supply from year to year and the risk of heavy snowfall in winter, trapping a flock on the mountain where it will starve.

In the Western High Atlas, climatic averages give a false impression of stability of moisture supply from year to year. The average annual river flow of the watershed, measured from 1970 to 1983, was 1.5 cubic meters per second. But this varied from 0.4 to 2.9 cubic meters per second respectively, in 1982-83 and in 1970-71.(26) Though I lack range-forage-supply data for these years, I assume that forage production also varied over the 13 years in partial response to moisture availability (among other factors). Local shepherds confirm this modest assumption, expecting a rich supply of forage for flocks following winters of heavy precipitation and flock starvation following winters of low precipitation.

Berber shepherds respond to this uncertainty with a certain degree of resignation. Imenane flock owners, who regularly buy outside forage for their cows, apparently never buy trucked-in forage for their flocks. Their

reasoning: in a long-lasting drought, the flocks will starve to death eventually, so why throw good money (in buying hay or straw in the market) after bad (ie, the starving flock)?

The other climatic risk facing Imenane flock owners is that of unexpected deep snow that can trap a flock indoors for several days. This sudden starvation, coupled with the chronic starvation typical in winter and the stress to animals from severe fluke infestations, can lead to catastrophic flock mortality. One flock owner described the deaths of 40 sheep in his flock over several days in winter.(27)

Households meet this challenge by diverting hay, which is normally fed to cows in winter, to the flock when it is snow-bound. The duration of this emergency feeding of the whole flock is short -- as little as 4 days in 1985 in one flock and no more than 25 days in 2 other flocks observed. The amounts fed per animal were small: from 0.1 to 0.3 Kg per head per day, or about 0.4 to 1 percent of live body weight of a typical ewe. The percentage of each household's total hay crop fed to the flock during these emergencies varied in winter 1984-85, but was not more than 50% for any household studied.(See Table 4)

On snow-bound days, flock owners also supplement the entire flock from the nearby irrigated pastures. They shovel the snow and herd the entire flock on these pastures that are usually saved for grazing by only lactating females.

3. ECOLOGICALLY ADAPTIVE DEVELOPMENT POSSIBILITIES

Berber agropastoralists use seasonal flexibility to overcome environmental constraints to animal production. By raising range-fed small ruminants, they are not limited by the small, forage-producing capacity of irrigated land. By transhuming, they avoid stresses and exploit opportunities that occur seasonally on rangelands along the elevation axis of the mountain/plains complex. The seasonal flexibility in range use allows flocks to be moderately productive with a minimal input of agriculturally produced, local or imported supplements.

A production strategy of minimal inputs may not be as productive as a modern, intensive, flock management that controls more environmental factors. But minimal use of limited inputs, coupled with seasonal flexibility in range use, may be the only realistic model for pastoral development wherever arable land, water and capital are severely limited, but uncultivable rangeland is abundant.

Such a development model, maximalist in its adaptability to the environment, minimalist in its use of limited resources and modest in its projections of improved productivity, can be illustrated in the Imenane Valley. Extension might suggest that shepherds prevent breeding from May to August. The offspring of these matings, born from October to January, seem to seldom receive adequate milk. without any extra use of supplemental forage for flushing, animals would tend to breed from February to April in years with winter transhumance. In other years they would breed in September and October while grazing the reserved late summer-fall range. Offspring of these matings, born from July to September, or in February and March, would more likely receive adequate maternal milk.

Another suggestion might be to defer grazing in spring and summer on ranges near villages. Shepherds would then use more distant, higher elevation ranges, saving range forage near villages for use in winter, when higher elevation ranges are snowbound.

Both suggestions obviously pose problems for labor allocation and for land control. But looking for the moment only at the ecological component of range livestock production, both would improve the synchronization of animal needs and forage availability at little cost in land, water or capital.

4. SUMMARY AND CONCLUSIONS

Berber agro-pastoralists in Morocco's Western High Atlas must exploit the extensive rangelands surrounding their small, mixed farms. They use a traditional strategy of animal production adapted to the mountain, range-animal ecology. They must overcome constraints of fluctuating forage supplies , of cyclical fluctuations in flock nutritional needs and of uncertainty in forage availability from year to year. They overcome these constraints by transhuming with their flocks over the 3500m elevation range of vertical ecology of the mountain/plains complex. When the flock's nutritional needs are high but forage availability is low, flock owners supplement their flocks from the small arable surface. Agricultural complementarity also lessens the risk of the flock starving while snow-bound. But long-term drought is accepted by flock owners who let their flocks starve when range forage is in very low supply.

This animal production strategy is minimalist in its use of farm inputs of water and arable land. It relies instead on flexibly responding to cyclical and year-to-year changes in ecological relationships between livestock and forage.

Farming Systems researchers may also wish to enhance the agro-pastoral complementarity of mixed farms in regions where land and water are similarly limited, but where surrounding wastelands are extensive. In order to do so, the research team must understand the ecological relationships between range and livestock.

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Footnotes

1. Agency for International Development. 1980. p. 8.

2. Little, P. 1982. p. 4.

3. Agency for International Development. 1985. pp. 11-12.

4. The study area contains the villages of Tachdirt, Ouanskra (with Talat n' Chaote) Tamguist (with Tineghourine and Azdowkhs) Ikkis, Amsekrou, Arg and Ousertek (including the separate villages of Glis, Agadir, Imsoughene, Tidli and Tineghouar). Rural Tax Records for 1979 list 284 households in the area.

5. The culture, natural environment and agropastoral production described for the Imenane valley are very similar to a general description of the eastern, higher end of the Western High Atlas. See Bencherifa, 1983, pp. 273-279.

6. Black-and-white, 1:50,000 scale aerial photos, taken around 1965, were enlarged to 1:10,000 and "ground-truthed" in 1985. A 1:100,000 scale, topographic map, "Oukaimeden-Toubkal", was used. No corrections were made for slope, so that the total watershed area is underestimated. The area of irrigated fields, which are usually more level, is more accurately estimated. Because of the space occupied by retaining walls between

terraces, actual cultivated area is much less than the area within the irrigated perimeter. Therefore, I performed several photo transects to crudely estimate the proportion of actually cultivable terrace land to uncultivable terrace walls. Total area within the irrigated perimeter was then multiplied by the estimated percentage of actually cultivated area in order to estimate actually cultivated area.

7. One very prosperous household (Bounagzat, listed as #5 in the Tables) and three relatively prosperous households (Askari ait al Taleb, #6; Badi, #2; Azougagh, #1) were interviewed in Tachdirt and Tineghourine. Two much poorer households (Ait Shkort, #3; Bijaou, #4) were interviewed in Arg and in Tidli, respectively. The movements of the Bounagzat flock are illustrated in Figures 1 and 2.

8. Data for Asni (1200 m elevation) from Sept. 1977 to July 1985. Compare this to a higher 30-year average, from 1933 to 1963, of 486 mm/year. See Chami, 1982, p. 5.

9. Calculated from data for the administrative "Rural Center" of Asni presented by Chami, 1982, pp. 12 and 16. The neighboring Azzaden valley has a density of 12 persons/irrigated hectare. See Bourbouze, 1984, p. 19.

10. Calculated from total irrigated land (measured on aerial photos) and number of taxable families in 1979.

11. The Marinids broke the power of their mountain opponents, the Seksawa, by blocking access to the Seksawa's grain fields and winter pastures on the Haoz Plains in the 14th Century. See Berque, 1955, p. 58.

12. Op. cit. pp. 99-102; Bourbouze (no date) p. 196.

13. Household #4, with 100% of its flock on irrigated pasture in December and January is an apparent exception. But adult flock consisted of only two female goats, intensively managed for regular, twice-yearly parturitions.

14. Meteorological Stations at, respectively, Amzmiz and Tizi n' Test. From Chami, 1982. p. 5.

15. From Chami, 1982, p. 10; who quotes Voinet (no title given) in 1928, who quoted a certain Dr. Maire, describing the neighboring Ourika Valley.

16. Precipitation comes to Marrakech during the relatively warm winter, when native ranges produce succulent forage. The average temperature for July and August is 29°C while, of course, mid-day maximums are much higher. Flocks native to the Haoz are said to need barley straw or beet pulp as supplements in the summer, because the desert provides little forage.

17. A four-year average (1981 to 1985) of daily minimums in Dec, Jan., and Feb. of -2°C, ranging as low as -15°C. Oukaimeden is used as a winter ski resort, with meter-deep snow not uncommon.

18. Bourbouze (no date) p. 155.

19. Mr. Moulay All at the Asni office of the Department Provincial d' Agriculture. Personal communication.

20. They do this in spite of the option of moving the flocks by truck, which many owners do in winter, when moving flocks from the mountains to the Plains.

21. Belschner, H.6. 1965. pp. 650-657.

22. Adult flock is a composite of 4 household flocks from Tachdirt and Tineghourine that varied in size from 272 to 329 head over the 16-month period of data.

23. Spedding, C.R.W. 1970. pp. 77-78.

24. Op. cit. p. 110

25. Refers to Bounagzat flock, which transhumed to the Haoz on 1 Feb. 1985. The shepherd was interviewed on 13 Feb.

26. Data from the Oued Rherheya Station at Tahanaout, collected by the office of Resources en Eau.

27. Badi, in the fall and winter of 1983-84.

28. Map traced and elevations transferred from the map, "Morocco", scale 1:2,000,000. Published in the United States by the Geographical Section of the General Staff, in 1942, copied from a French map entitled "Maroc", published in 1939.

29. Map traced and elevations transferred from map "Oukaimeden-Toubkal", see above. The elevation of the early summer flock pen is shown on the profile; the pen itself (Nirt) is farther to the west.

Table 1 Small ruminants supplemented with irrigated pasture, as a percentage of each of 6 households' flocks. Upper Imenane 1983k-84.* Mendes. CRSP-Small Ruminant Project.**

Percent of Household's Flock on Irrigated Pasture

Households	October-November 83 %	December-January 83-84 %	February -March 84 %	April 84 %
1	0	30	30	9
2	0	20	20	1
3	0	0	0	0
4 (13)	0	100	0	0
5	0	30	40	40
6	30	30	30	0

* 1983-84 was a winter without transhumance, due to low rainfall on the Haoz Plains. Therefore, the flocks were present in the Imenane throughout the winter.

** Practically no small ruminants grazed irrigated pastures from May to Sept. 1984.

Graph 1: Increasing precipitation with increasing elevation in the Rhereya watershed. 10 year averages from Chami 1982, p.5.

Elevation m	Station		Precipitation m
3000	Neltner	(3207m)	896 _____
2500			
2000			
	Aremd	(1900m)	609 _____
1500			
	Asni	(1200m)	459 _____
1000			
	Tahnaout	(900m)	300* ____

*2 year average only.

One (___) represents 50 mm precipitation.

Table 2: Sheep and Goat mortality, as percent of total adult flock (16) in each two-month period. Data consolidated from four household flocks in Imenane valley studied in 1985 by Mendes, CRSP-Small Ruminants Project.**

Months*:	Oct-Nov/83	Dec-Jan/84	Feb-Mar/84	Apr-May/84	June-July/84	Aug-Sept/84	Oct-Nov/84	Dec-Jan/85
Sheep	10%	11%	0%	1%	0%	0%	0%	2%
Goats	0%	9%	0%	0%	0%	0%	2%	1%

* Months in the Julian or Felahi calendar, 13 days later than the Western, Gregorian calendar.

** This was a winter in which the flocks did not transhume to the Plains.

Table 3: Lamb and kid mortality as a percent of each tow-month period's parturitions. Data consolidated from four household flocks in Imenane valley studied in 1985 by Mendes, CRSP-Small Ruminants Project.

Month*:	Oct-Nov/83	Dec-Jan/84	Feb-Mar/84	Apr-May/84	June-July/84	Aug-Sept/84	Oct-Nov/84	Dec-Jan/85
Lambs	NA	24%	0%	0%	NA	NA	0%	21%
Kids	NA	26%	0%	0%	0%	0%	0%	88%

* Months in the Julian or Felahi Calendar, 13 days later than the Western, Gregorian calendar.

No births in months marked NA

Table 4: Hay fed to small ruminants in 6 households of the Upper Imenane Watershed. 1985 case studies by Mendes, CRSP-Small Ruminant Project.

Households*	Kg Hay Harvested	Hay Fed to Flocks 1984-85	
	Kg	Kg	% of All Hay
1	900	300	30
2	300	0	0
4	100	0	0
5	2000	900	50
6	2000	80	4

* Household 3 produced no hay and is not shown.

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