Report of the Cropping systems working group

7th Cropping Systems Working Group Meeting
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CROPPING SYSTEMS WORKING GROUP

MEMBERS

1.	Damkheong Chandrapanya	-	Department of Agriculture Thailand
2.	Virgilio Carangal	-	International Rice Research Institute Philippines
3.	Suryatna Effendi/ A. Syarifuddin K.	-	Central Research Institute for Agric. Indonesia
4.	Walter Fernando	-	Department of Agriculture Sri Lanka
5.	Arturo Gomez	-	University of the Philippines at Los Banos Philippines
6.	Yusof Hashim	-	Malaysian Agricultural Research and Development Institute Malaysia
7.	Zahidul Hoque	-	Bangladesh Rice Research Institute Bangladesh
8.	K.R. Kulkarni	-	All India Coordinated Agronomic Experiments India
9.	Shiva Lohani	-	Department of Agriculture Nepal
10.	Tung Saing	-	Agricultural Research Institute Burma
11.	Yong Hwa Shin	-	Office of Rural Development South Korea
12.	Hubert Zandstra	-	International Rice Research Institute Philippines

CROPPING SYSTEMS WORKING GROUP

RESOURCE PERSONS

1.	Gordon Banta	-	Department of Agriculture Thailand
2.	L.Dale Haws	-	International Rice Research Institute Philippines
3.	Peter Hobbs	-	Bangladesh Rice Research Institute Bangladesh
4.	James Litsinger	-	International Rice Research Institute Philippines
5.	Alejandro Manzano	-	International Agrl. Development Service Nepal
6.	Sudarshan Mathema	-	Department of Agriculture Nepal
7.	Jerry McIntosh	-	Central Research Institute for Agriculture Indonesia
8.	Keith Moody	-	International Rice Research Institute Philippines
9.	Richard Morris	-	International Rice Research Institute Philippines
10.	Arwooth Nalampang	-	Department of Agriculture Thailand
11.	Edwin Price	-	International Rice Research Institute Philippines
12.	Richard Tinsley	-	International Rice Research Institute Sri Lanka
13.	S. H. Upasena	-	Department of Agriculture Sri Lanka

CROPPING SYSTEMS WORKING GROUP

COMMITTEES

Topic		Composition[1/]
An evaluation of the IRRI Cropping Systems Program in relation to national program needs	-	Zahidul Hoque Suryatna Effendi/ A. Syarifuddin K. Arturo Gomez
Techniques for on-farm cropping systems research	-	Hubert Zandstra Peter Hobbs Hugo Manzano
Length of time required in a research site	-	Shiva Lohani Damkheong Chandrapanya Richard Tinsley
Analysis of data collected in cropping pattern monitoring	-	Richard Morris Damkheong Chandrapanya Shiva Lohani
Plans for cropping systems conference	-	Virgilio Carangal Jerry McIntosh Yong Hwa Shin
Varietal screening and testing	-	Arturo Gomez Arwooth Nalampang Tung Saing
A collaborative project in entomology for cropping systems programs	-	James Litsinger Walter Fernando
Collaborative research: Weed control	-	Keith Moody Zahidul Hoque K. Kulkarni
Collaborative research: Cropping systems economics	-	Edwin Price Sudarshan Mathema Gordon Banta Yusof Hashim John Flinn

AN EVALUATION OF THE IRRI CROPPING SYSTEMS PROGRAM IN RELATION TO NATIONAL PROGRAM NEEDS

Introduction

Perhaps the single most important development in agricultural research in South and Southeast Asia in the recent years has been the emergence and adoption of the cropping systems research approach which is based on efficient resource utilization through multiple cropping for maximum food production and farmers' economic welfare. And the International Rice Research Institute is the pioneer research center to develop the concept, test it and spread throughout the region. IRRI's own program itself has undergone several evolutionary changes. Initially, the approach was to test various ways of intensifying land use without regard to cost of production and existing farmers' capabilities. This was a phase of biological exploration. This was followed by a phase wherein the designed systems were evaluated for its socio-economic feasibility. This was ultimately followed by the third phase-cropping systems research in farmers' fields taking into account the physical, biological and socio-economic factors. The development of this site-specific research concept is a significant step towards putting agriculutral research at the immediate services to the farmers, which has greatly benefited. The flow of information to national program was even more enhanced with the organization and regular meetings of the Asian Cropping Systems Network composed of researchers in multiple cropping in the region.

The purpose of this paper is to review the IRRI contribution to the national cropping systems program in the past and to assess the future support/assistance needs of different country programs that could be offered by IRRI.

Goal and Objectives of Cropping Systems Program

In order to recognize the significance of the national cropping systems program activities and IRRI contributions to it, it is worthwhile to bear in mind the general goals and objectives of cropping systems research. These are listed below.

1. Increased food production. One of the most important objectives of rice-based cropping systems program is to increase food production to feed the growing millions in the south and southeast Asia. Considering the higher growth rate in population, has become a most for these countries. The other important reason for increasing food production per unit area is to harness the potential production that is possible under tropical and sub-tropical situations.

2. Better nutrition. People in the rice-growing countries in Southeast Asia have been suffering from malnutrition. Their cereal diet needs to be improved in terms of nutrition. However, since much of the farmers

food came from their produce in the farms, crops grown by the farmers indirectly influence their health and nutrition. Our focus of recent cropping systems research has been to produce in the farm crops that will improve nutrition of farm families.

3. Farmers' economic welfare. The cropping systems programs should look into the overall economic welfare of the small farmers. Mere increased production and improved nutrition might not help the farmers. The farmers should be provided with alternative choices of cropping patterns that he can use in variable market and environmental situations. The ultimate goal is to attain maximum economic return from cropping.

4. Increasing farm employment opportunity. In most of the southeast Asian countries farm labor has been rather cheap and plenty. Intensive cropping systems are needed to ensure increased farm employment and better utilization of available labor on the farms. This is possible through the development and adoption of judicious cropping patterns that will create year-round labor requirements with maximum economic returns.

5. Improving samll farmers' bargaining position. Because of the poor economic background the small farmers usually possess less bargaining capacity in terms of marketing their products. Because of their strong needs for cash they are often compelled to sell their produce at lower prices. Attempts are now being made to design the cropping systems for small farmers in such a way so that they do not fall victim of such situations as well as they attain more bargaining power in the existing marketing systems.

6. Aid national agricultural development program. In most of the Southeast Asian countries, the national governments are undertaking large-scale production programs to increase food production immediately to bridge the food gaps. These production programs are based on mono-crops or on cropping patterns that are selected mostly without any research on pre-testing One of the most important objectives of today cropping systems research program is to generate useful information and backup these national production programs. The cropping systems research programs can help the national governments in designing and monitoring the production programs.

With these above-mentioned broad goals and objectives, the cropping systems programs should generate useful information that can be directly used in the production programs designed for increased food production in relevant areas.

Approaches to Cropping Systems Research and Development

The recent approach to cropping systems research and development can be divided into several steps, namely:

1. Agro-climatic classification. Agro-climatic classification of a country or region is done to characterize the country/region from agro-climatic point of view as well as to divide the country/region in different

agro-ecological zones. This help in undertaking the performance of existing cropping patterns, development of new cropping patterns and extrapolation of useful research data from one site to another similar site.

2. Site selection and description. A specific site representing an area with higher potential for increased production is selected for research. The site is described in terms of existing cropping systems, resource base of the farmers, agro-climatic conditions and constraints to crop production.

3. Integrating physical, biological and socio-economic factors into a conceptual model. Conceptual models are developed integrating or considering the physical, biological and socio-economic variables at a site finally to develop productive, profitable and stable cropping patterns. Success in developing and implementing an appropriate conceptual model can largely contribute to the bit and stability of the developed cropping patterns to the existing farming systems.

4. Site specific research. Cropping pattern testing and studies on component technologies are done at the selected site after adequate site description through systematic benchmark studies. Experiences obtained at the experimental station research are used in working at the sites.

5. Pre-production research. When potential cropping patterns are developed through site-specific research in farmers' fields, these are tested further in pilot production program to determine their adaptability and profitability on a larger scale.

6. Production programs. The cropping systems research program should be linked up with the production programs in the respective areas. The research should really be a component of the whole program that can substantially help design the production program by selecting appropriate cropping patterns and component technologies for the production program; monitoring the production program and collecting feed-backs for future guidance in research and extension.

Recently, the cropping systems scientists are also considering a wider framework for research. This framework include things as follows:

1. Cropping systems include all commodities (crops) including rice. Work should be done on the other crops of the systems in the context of the cropping systems. The work on these other crops may include sector studies like those on land capability, infrastructure, markets, credit, government policy.

2. Cropping systems need to be studied as a component of the whole farming systems. Wider framework embodying cropping systems as a component is needed. Research methodologies should be developed to study cropping systems in the context of the whole farming systems framework

3. Large-scale national production programs should be strongly supported by the cropping systems programs.

IRRI Cropping Systems Program

The IRRI cropping systems program has the following projects:

1. Environmental classification. Because of IRRI's involvement in the development of cropping systems in the region, IRRI has been working on the environmental classification in the Southeast Asian region. An agro-climatic survey has been completed in Bangladesh and work in other countries like Indonesia is also in progress. These project will help the IRRI program in extrapolating results from one site to another similar site in the region.

2. Design of cropping patterns. Potential cropping patterns are being designed for the experimental stations and specific sites for testing.

3. Testing of cropping patterns. The potential cropping patterns are being tested from agronomic as well as economic standpoint at the station and farmers' fields.

4. Component technology development and evaluation.

5. Pre-production evaluation.

6. Asian cropping systems network.

The whole range of IRRI cropping sytems activities fall under two components: research and cropping systems network.

A. Research Component

The IRRI research component has the following activities:

1. Site specific research on cropping patterns. IRRI has two sites at Iloilo and Pangasinan in the Philippines. The site at Batangas has already been over. The IRRI program is trying to improve the existing cropping patterns as well as to develop new potential cropping patterns and management systems for increased production at the sites. The results on the cropping patterns testing at IRRI sites can be used in the Philippine national production programs through better linkage.

2. Development of methodologies for site-specific research. The most important contribution of IRRI site-specific research has been the development of methodologies for agronomic and socio-economic research. These methodologies on benchmark surveys, cropping pattern testing, agronomic component technology development through super-imposed trials, pest management, environmental monitoring, farm record keeping and data analysis have been useful for the national programs in the network. However, more work is needed in this aspect to develop simple appropriate methodologies for site-specific research that can be easily adopted and used by the national programs. Particularly, there is a strong need in the network for methodologies on socio-economic aspects of cropping systems.

3. Component technology development. IRRI program has been putting a lot of emphasis on the component technology development for the sites. Work on the component technologies like stubble planting of upland crops done at IRRI may help many national programs in the network.

B. Cropping Systems Network Component

The most important contribution of the IRRI program to the development and upliftment of the national cropping systems program has been through the IRRI cropping systems network. In short, the network has provided the following services to the national programs:

1. Catalytic and consultative services. IRRI program has significantly contributed towards the initiation and development of different national programs. IRRI persuation has inspired the national governments to set up cropping systems program to a greater extent and the consultancy provided by the experienced IRRI scientists has contributed a lot to the program development and implementation of different national cropping systems research program.

2. Arrangement for financial aid. Many national programs needed financial aids from the international donors. IRRI has acted as a reliable medium for arranging such financial grants. In some cases, IRRI has been administering the funds from the donors for the national programs.

3. Training and orientation program on cropping systems. Training is an essential component for any program. IRRI has helped the national programs in training the research workers in 6-month cropping systems training program, graduate degree programs as well as in motivating the research administrators through observation and orientation programs. The number of people receiving IRRI training and orientation from different countries is shown in table 1.

4. Plant materials. Suitable crop varieties are a pre-requisite to the development of intensive rice-based cropping systems. IRRI network has supplied the national programs sets of varieties, collected from different sources,depending on the needs of the national programs. Many of the varieties supplied by the network coordinator to the national programs have already exhibited greater potential for bit into the intensive cropping systems in different countries. The records on supply of plant materials by the network to the national programs are given in table 2.

5. Working group meeting/workshop/symposium on cropping systems. The establishment of a working group consisting of the national cropping systems program leaders and resource persons by the IRRI network has been a tremendous step towards a meaningful coordination in cropping systems research and development in the region. So far, seven working group meetings have been held in which experiences from different countries have been discussed as well as special topics on cropping systems discussed. A symposium on cropping systems held in 1976 at IRRI contributed a lot towards the understanding of cropping systems science, present status of

cropping systems research, research methodologies and future considerations for cropping systems research and development in different countries. Records on cropping systems meeting organized through the network are presented in table 3.

6. Exchange of information. The network provided the national programs with useful reference materials and literature on cropping systems. There has been also exchange of research information among the country programs through the network. Collection of information by the network at IRRI from different country programs and their selective distribution could really be immense value to the cropping systems research and development in the region.

Potential Areas for IRRI Cropping Systems Program's Contribution to National Cropping Systems Programs

As it has been mentioned earlier, since IRRI's mandate is to help increase food production in the region, IRRI cropping systems program will have to continue to support the national cropping systems program in all possible ways. Figure 1 presents the potential areas for IRRI contribution to the national cropping systems programs. As it is clear from the chart in figure 1, IRRI program can help the country program in the following areas:

1. Help government adopt cropping systems approach for agricultural research.

2. Provide consultative services in different stages of the program.

3. Train national research workers.

4. Help the national programs in getting financial assistance from international donors.

5. Supply and exchange of literature, technical and plant material.

6. Exchange of ideas and experiences through working group meetings, conference, symposium and monitoring tours.

7. Conduct collaborative researches with the national programs.

8. Help evaluate the national cropping systems research program.

It has been felt necessary that the IRRI cropping systems network should be further strengthened in terms of senior level manpower to provide adequate services to the country programs. Particularly, there is a felt need in the network for an experienced economist with good background in cropping systems research.

National Program Needs

The program leaders/representative of different country programs in the network were asked through a questionnaire about their needs, particularly that could be offered by the IRRI program. The needs, as ascertained from the answers, could be categorized as follows:

1. Short training at IRRI.
2. Degree training at IRRI.
3. Development of incountry training program.
4. Consultative services.
5. Collaborative researches.
6. Supply of seed materials and publication.
7. Workshops, conference and monitoring tours.

The training slots needed by different countries in 1979-80 are presented in table 4. The areas of collaborative cropping systems research as suggested by different country programs are presented in table 5.

Future Expectation from IRRI Program in Cropping Systems Research to Help National Cropping Systems Research

Because of the high capability and resource availability of the IRRI program, it was felt that IRRI program should undertake in-depth cropping systems research that can not be easily undertaken by the national programs but very much useful for them. A few potential areas for IRRI research are suggested below.

1. In-depth studies might be very important in learning whether farmers' cropping systems can be maintained or improved or whether it should be replaced entirely. IRRI can give a good contribution on this by putting outreach sites research using several models in several agro-climatic zones and will come up with a model or models that can fit to the regional conditions. Here emphasis is on the model development.

2. Specification for crops and varieties for a given situation should be developed. In fact, this is in progress. IRRI can have a germplasm collection. The materials can be reproduced and tested in the regions. Multi-location testing may help to identify in a short time the suitable varieties for the region.

3. Coordinated research on cropping systems in rainfed areas should be emphasized. IRRI's role is to develop production models integrating soil, plant and climatic factors. Models can, then, be further tested by super-imposing on the socio-economic condition existing in the farming systems.

4. IRRI needs to study alternative sources of power as well as farm equipment in real farm situations. A series of research trials can be undertaken involving several combinations of human, animal and mechanical power to compare the resulting areas under cultivation, changes in labor productivity (per family unit) and production and net returns for individual crops and cropping patterns. This study can be held at IRRI, outreach sites as well as in the national programs.

5. Most of the Southeast Asian countries have high population densities and poor economic background of the farmers. Improved cropping systems involving improved technologies and management practices in these situation need cooperative efforts on the part of the farmers. Cooperative efforts are needed in factors like irrigation, mecbanized land preparation, threshing, drying, other post-harvest operations and marketing. Pilot research project should be undertaken on cooperative farm management systems in the context of cropping systems.

6. IRRI can contribute to set up some research and models that can be fit to regional condition to accelerate and to develop the method for fast short-cut production program as a pioneer in contributing self sufficiency in food as well as strengthening farmers economy. Pilot production program research can be done in few locations in different countries.

7. Research on agri-business covering the major aspects of infrastructure, socio-economic factors influencing agricultural development should be initiated. The agro-economic component of cropping systems research should start dealing with research on the agri-services, including extension, farm input supply distribution banking and credit system, processing, marketing and socio-ecological preconditioning of the area.

<u>Committee</u>: M. Z. Hoque

A. A. Gomez

S. Effendi/Syarifuddin

Table 1. Cropping systems training/study tour/observational tour records at IRRI since 1974.

Country	No. of trainees completed short course (4-6 months) at IRRI*	No. of graduate students		No. of officials observed IRRI cropping systems program			Total/ country
		MS	Ph.D	High level	Medium level	Junior level	
Finish already		5	4				
Thailand	21 + 5	7		2	8		52
Indonesia	42 + 20	5	2	3	4		76
Bangladesh	8 + 9	4		1			22
Nepal	4 + 3			1			8
Philippines	30 + 3	3		3			39
Sri Lanka	7			2	5		14
Burma	6	1		1	1		9
South Korea	3						3
India	2			2			4
Malaysia	5 + 3			1	3		12
Japan	1						1

* + means undergoing training now.

Table 2. Seed materials sent from IRRI to the national programs (1976-77).

Crop	NUMBER OF TRIALS										Total
	Thailand	Indonesia	Sri Lanka	Burma	Malaysia	Bangladesh	India	Nepal	Taiwan	Phil.	
Corn	3 (12)	2 (10)	2 (11)	2 (15)	-	2 (14)	2 (10)	-	1 (17)	8 (15)	22
Sorghum	4 (15)	2 (15)	1 (15)	1 (15)	-	2 (17)	-	-	1 (16)	8 (15)	19
Soybeans	6 (8)	3 (7)	2 (4)	2 (15)	1 (8)	2 (8)	-	1 (10)	-	6 (10)	23
Mungbeans	6 (15)	3 (9)	2 (5)	1 (15)	2 (14)	2 (14)	1 (9)	1 (15)	1 (15)	8 (15)	26
Peanut	2 (11)	1 (10)	2 (13)	2 (10)	1 (7)	2 (11)	-	1 (9)	1 (10)	6 (15)	17
Cowpea	2 (15)	2 (10)	2 (5)	1 (13)	1 (9)	2 (14)	1 (9)	2 (11)	1 (14)	8 (15)	22
Sweet potato 1/	1 (12)	-	-	-	-	-	-	1 (11)	-	4 (10)	6

( ) Number inclose indicates number of entries sent not including their own local check.

1/ Except in the Philippines all materials sent were for multiplication, and observation.

Table 3. Cropping systems working group meeting/workshop/symposium records.

No. of meeting	Institute/organization & country sponsored	No. of		Copies of proceedings		Major discussion topics
		Participants	Observer	printed	circulated	
1. First Working Group together with Workshop of Cropping Systems March 18-22, 1975	IRRI	55	27	500	490	- National Multiple Cropping conditions, research and prospect. - National multiple cropping program. - Experiences with intensive cropping systems - Network need and program.
2. Second Working Group; Indonesia Nov. 3-8, 1975	CRIA, Dept. of Agr., Indonesia/ IRRI	18	-	300	295	- Cropping Systems research methodologies - Economic research methodology - Varietal testing - Training method and needs - Plans for symposium & meeting
3. Third working group, Thailand	Dept. of Agric. Thailand/IRRI	24	12	300	295	- Design and testing cropping pattern - Economic analysis of croppig system - Cropping Systems Informatior delivery system - Weed control research methodology - Varietal testing

Table 3. (Cont'd)

No. of meeting	Institute/organization & country sponsored	No. of		Copies of proceedings		Major discussion topics
		Participants	Observer	printed	circulated	
						- Approach to production - Plan for symposium
4. Cropping Systems Symposium, Sept. 21-24, 1976	IRRI	66	23	500	450	- Framework for cropping systems research and development for the Asian Farmers - Physical aspects of cropping pattern design - Economics of cropping systems; description and pattern design. - Testing of cropping patterns - Component technology - Cropping systems approach to adaptive research - Cropping systems approach to production programs.
5. Fourth Working Group Meeting	IRRI	12	18	300	285	- Environmental classification - Farmers participant research approach - Development of in-country training program - Varietal testing - Direct seeding rice - Handbook for economic analysis - Superimposed trials on cropping pattern.

Table 3. (Cont'd)

No. of meeting	Institute/Organization & country sponsored	No. of		Copies of proceedings		Major discussion topics
		Participants	Observer	Printed	Circulated	
6. Fifth working group meeting Bangladesh Feb. 15-22, 1977	BRRI, Bangladesh/ IRRI	11	17	200	235	- Environmental classification - Varietal screening - Time required to stay in each site - Coordination between research and extension in cropping systems research & development - Task of the network - Utilization of research outcome across the network - Pest control in cropping systems - Country progress report
7. Sixth working group meeting Sri Lanka Dec. 13-17, 1977	Dept. of Agric.	12	18	200	220	- Cropping pattern monitoring - Varietal testing - Economics handbook - Country report (15)

Table 4. Training needs in cropping systems in different countries during 1979-80.

Country	No. of slots needed for IRRI 6-month cropping systems training during 1979-80	No. of graduate training program needed in 1979-80	Total
Nepal	6	Will have to be decided	-
Thailand	10	4	14
Bangladesh	16	4	20
Burma	9	3	12
Philippines	3	Needs adequate number	-
South Korea	3	2	5
Indonesia	30	10	40
India	4	4	8
Sri Lanka	-	-	-
Malaysia	6	-	6

Numbers are given on the basis of the report of the country program leaders/representatives.

Table 5. Areas for collaborative cropping systems research between IRRI and the national cropping systems programs (based on the reports of country program leaders/representatives.

	Collaborative research areas	Countries Suggested/need
I.	IRRI consultancy for national research program	Nepal, Bangladesh
II.	Supply of seed materials for research	Thailand (rice, mungbean, sweet potato, peanut, cowpea) Malaysia (upland crops)
III.	Establishment of research facilities (pot culture sheds, glass house, seed storage)	Burma
IV.	Development of new and better technology	Philippines
V.	Methodology for interpreting results from various trials at different locations	Philippines
VI.	Easy method of evaluating pest infestation	Philippines
VII.	Regular exchange of information on research methodologies and progress	Malaysia, Bangladesh
VIII.	Collaborative research in (a) socio-economic aspects of cropping systems, (b) agro-climatology, (c) pilot production program and (d) component technologies	Bangladesh

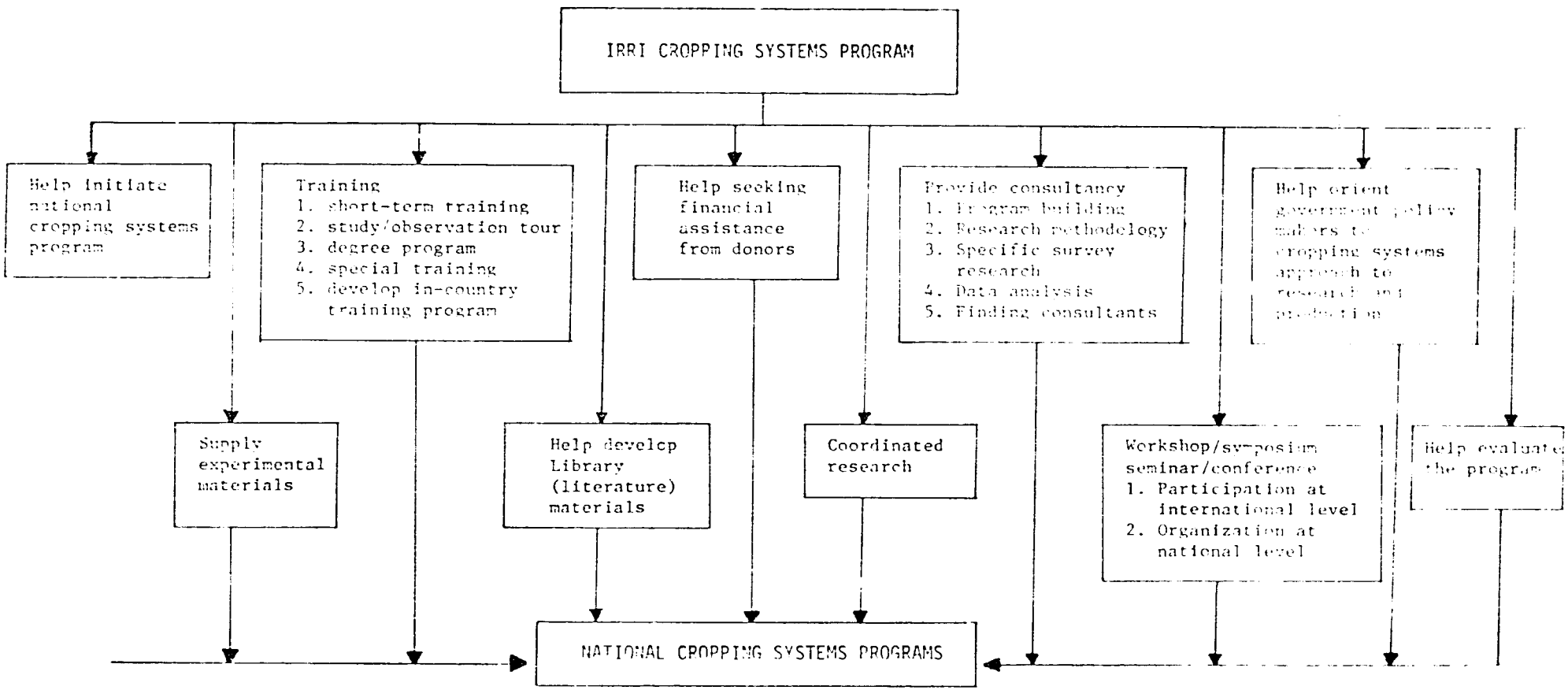

Fig. 1. Potential areas for IRRI contribution to National Cropping Systems Programs

TECHNIQUES FOR ON-FARM CROPPING SYSTEMS RESEARCH

Introduction

Methods for cropping systems research have been the subject of papers and Working Group Committee reports on several occasions during the course of 6th Cropping Systems Working Group meetings, the 1975 Workshop, and the 1976 Symposium. Of particular interest for research methods are papers by Harwood (1975), Gomez (1976), Litsinger (1976), Zandstra (1976), and the reports of the Working Group on "Farmer participant research approach" and on "Superimposed trials on cropping patterns" in the report of the Fourth Cropping Systems Working Group and the report of the committee on pest control in the Fifth Cropping Systems Working Group report.

From these sources it is clear that on-farm cropping systems research methods need to satisfy several requirements. They must specify ways in which an interdisciplinary team can compare the agronomic and economic performance of cropping patterns that differ in crop species, the number of crops, their establishment times and their management. In addition to this, the team needs to evaluate component technology for establishment, fertilization, insect, weed, and disease control. Thirdly, the research team must be able to study specific problems affecting crop production in general such as microelement deficiencies or toxicities or special disease or pest problems. The methods must also not exceed the team's capability; nor must it force a discipline to devote time on a problem of low priority.

The cropping systems research methodology developed by the Working Group strongly stresses the use of site description and analysis as a point of departure for the design of research at a site. Site description will identify what variables are to be studied and what ranges of these variables should be considered in the treatments. It will also identify the location and distribution of trials across clearly delineated land types.

On-farm cropping systems research also must allow economic analysis of alternatives tested. The research must be conditioned to the farm resources that can be obtained at the sites, particularly the farm implements and labor availability. In addition, cropping systems research actively pursues the participation of the farmer, as was extensively discussed in the report of that subject during the Fourth Cropping Systems Working Group Meeting (pp. 8-13).

This committee will focus its discussion on field plot techniques that can be used for on-farm cropping systems research. It will propose a format for field plot research that will encompass different field plot designs for different research requirement at the site. This format can be used to study different variables over different ranges in the different

network sites. The criteria and format for experimental design and analysis should however, be sufficiently similar to allow easy interchange of information. Such increased uniformity will provide the Working Group with a base for the development of guidelines for analyses and interpretation by researchers in the many network sites. It is also hoped that some of the complexity and confusion will be removed in the process of casting on-farm cropping systems research in a more uniform format.

SITE DESCRIPTION AND ANALYSIS FOR RESEARCH PROGRAM DESIGN

Zandstra (1976) described the use of environmental description for the identification of land types. As has been the practice in the network sites land types must continue to be identified on the basis of the most important determinants, that is, those factors that most strongly influence the peformance of cropping patterns in the area. Careful observation and study of existing cropping systems in the area generally give important indications of what these factors may be. So far our experience has been that in wet land production complexes soil physical (profile texture, clay type) and hydrological variables (seepage and percolation, enrichment potential or hydromorphicity) are most useful for the identification of land units; in dry land production complexes -- slope and soil chemical factors (pH, organic matter, or cropping history related fertility) become more important.

Having identified the important land types a research team needs to select 2 to 4 landtypes that represent major production areas in the site and in the region or country. Further research will focus on the identification of improved production technology for each of these land types. The research team needs to consider which common production variables -- cultivar, crop establishment method, fertilization, insect, weed and disease occurrence -- are similar across the site and which of these may require separate treatments for each land type. This analysis will later help to interprete differences observed in experimental results. Site description also provides the research team with an idea of the common input levels used by farmers and the range of yield responses to be obtained from these inputs. This allows an approximate analysis of the returns-to-cash inputs that need to be achieved at the site and will help in the selection of treatment levels or studies on fertilization, insect, and weed control. In site description particular attention should be paid to the farmers' technology history. Cropping systems researchers should be aware of the extent to which farmers have experimented with technological alternatives. The reasons why they have incorporated some of these and rejected others for their production systems should be understood.

A first step in design of experimental on-farm research is for the team to familiarize itself with the research history in the area or in similar areas. This should give the team some idea of the yields achievable, the type of input responses they can expect, possibly information about the performance of different crops and varieties and the comparison of the performance of these to those actually used by farmers in the area.

Site description must also include extensive climatic analysis. This involves knowledge about the rainfall distribution (monthly and weekly means over as long as record as available) and a study of the time and probabilities of onset of rainfall and termination of rainfall (Morris and Zandstra, 1978). Where irrigation is available the team must acquire knowledge about the irrigation schedules, their frequency and dependability. If the onset of rainfall precedes the turnout of irrigation or the end of the rainfall is after the irrigation ceases, a careful analysis of these periods for the cropping potential is in order. The research team should attempt to establish the effective growing season for each of their landtypes using a fairly high probability level (P = .8). This will help them design cropping patterns that have a high probability of success. For wetland production complexes, it is particularly important that the research team get a feel for the periods in which the soil will be saturated or have standing water as opposed to the periods in which the soil will be primarily moist but not saturated.

DESIGN OF THE SITE-RELATED RESEARCH PROGRAM

The design of the research program for a cropping systems research site should be completed at least one month in advance of the first seeding date at the site. In most network programs the yearly research program is designed in a workshop format in which all researchers at the site participate. Site researchers should be given prime responsibility for the presentation of previous research results and should be encouraged to contribute their insight about the existing farming systems, the potential for increased production, and farmers' reactions to alternatives. The workshop should draw on the support of advanced cropping systems researchers and subject matter specialists in the areas of economics, entomology, weed science, plant pathology, soil fertility, and plant breeding. Researchers should expect this workshop to take from 3 to 6 days and although the research program for the site is designed before the cropping season starts, it may be useful to re-evaluate the research program after each crop and make the necessary modifications.

The following steps are suggested for the design of the research program at the site:

1. Decide on the landtypes to be studied at the site and describe each of these as precisely as possible. The team need not conduct research on all landtypes in their area of operation; generally by using 2 to 4 of the most important (common) landtypes the team can cover the vast majority of production situations at the site. At times, a landtype may be included because of its importance elsewhere.

2. Identify variables that in general adversely affect crop production, such as fertility problems, minor element deficiencies or toxicities or the common and dependable occurrence of crop pests.

3. Decide on the cropping patterns to be studied for each landtype. These patterns should be carefully designed in accord with the physical and socioeconomic conditions prevailing at the site. Farmer's cropping history, climate, product value, and potential market are all important factors to be considered.[1/] For each landtype the research team should probably limit itself to 3 or 4 cropping patterns. These patterns may be the same for different land types. In fact it is desirable that the performance of one or more patterns can be compared between landtypes.

4. Each cropping pattern needs to be assigned a management technology. Figure 1 is an example of the complexity of a cropping pattern and the information required with respect to component technology. As the research team considers different alternatives it must evaluate the expected response and the cost involved with each alternative. During the design of the cropping pattern a simple cost-and-return analysis is helpful in planning the management of the pattern.[1/] These factors should not be taken lightly as it has been estimated that to decide on varieties, tillage methods, planting methods, pest management, fertilizer additions, weed control methods, and harvest methods in addition to the timing of all operations, more than 30 decisions nee' to be made for a two-crop cropping pattern. Tables 1 and 2 present examples of component technology specifications.

During the first year the component technology chosen for the cropping patterns will depend primarily on information from the environmental description and previous research at the site and in similar sites. Over time more information on component technology will become available from research at the site and will increasingly form the basis for decision making about the component technology levels to be used for the cropping patterns.

5. As the team discusses the component technology to be assigned to the cropping patterns, it will also identify areas of lack of information that need to be studied at the site. This may involve varietal screening, insect, weed or disease control, soil fertility aspect, tillage methods, or the date of establishment of different crops. During the first year it is often useful to do time of planting trials for the important crops at the site over their potential range of planting dates. These trials should be monitored for the occurrence of insects and diseases whose severity is often strongly affected by planting date intervals as narrow as several weeks.

Component technology research is planned with respect to cropping patterns selected for experimentation. It normally addresses only one crop of the pattern sequence and one or two variables at a time, from among variables, such as variety trials, tillage methods and subsequent levels of weed control, or method and rate of nitrogen application, insect control methods - rates. In such trials all other component technology levels and management methods that are not being varied as

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[1/] See information required to design and test for economic criteria, page 36a to 36c, Fourth Cropping Systems Working Group Report.

part of the treatments must be the same as those specified for the same crop in the cropping pattern trials. Limits to seeding dates that apply to that crop in the cropping pattern must be applied to the component technology trials. This is important as it will allow linking of the component technology research results to those of the cropping pattern trials.

During the identification of the component technology research to be conducted at the site for that year or crop cycle, the team may need to adjust the component technology levels assigned to the cropping patterns. This is because much insight is derived from the discussion of component technology research trials.

EXPERIMENTAL DESIGNS

On-farm research in cropping systems now employs three types of experiments: research managed (small plot, replicated) trials, field-sized cropping pattern trials, and superimposed trials. Each of these satisfies different research objectives.

1. Research-managed trials

As discussed before these trials evaluate specific management components to be assigned to cropping patterns. They generally evaluate a wider range of management alternatives which is expressed in an increased number of variables and levels included in the treatments. Research-managed trials seek to understand more precisely the type of responses to input levels and evaluate high risk treatments about which too little information is available to be included in farmers' managed cropping patterns. The results of research-managed trials are analyzed with an emphasis on treatment differences and require considerable precision. These results determine future changes in cropping pattern management levels.

The experimental designs for research-managed trials will not be discussed in detail at this time. They follow the considerations of small plot experimental design on research stations. Because of limited field size, treatment numbers should normally be kept between below 12. The number of replications should be three or more except where multi-location testing is involved in which case within field replications should be reduced to two as long as the total number of replications is four or more. Normally replication should be such that error degrees of freedom is no less than 12.

Research-managed trials can be conducted at research stations if the environment (climate, soils) at the station is the same as that of the landtype or if the purpose is strictly to compare treatment differences and no strong interaction with the environment is expected. In such cases, the site research team requiring the information should encourage research-

ers on the stations to conduct such experiments. These trials should, however, use the same tillage methods and implements and the same component technology (for fixed management) as that used for the corresponding crop in the cropping pattern trials. For factors that are varied, one of the treatment levels must be that used in cropping pattern trials.

2. Cropping pattern trials

These trials compare patterns that differ in crop species or species combinations, the number of crops, their establishment method and time as well as their management. Cropping patterns are evaluated on the basis of their performance in the landtype for which they were designed. They are managed with farmers and in this way partially evaluate the farmers' capability to manage new technology and give feed-back of farmer's views of the technology. This gives opportunities for the identification of conflicts of the pattern with the farmers' resource base. Cropping patterns are tested in large* plots to allow measurement of labor and time required for the operations used in execution of the patterns. This in turn allows precise cost-and-return analysis for the patterns.

For the design of cropping pattern trials, the following general guidelines are suggested:

a. The research team should select 2 to 3 landtypes on which it wants to focus its research.

b. For each landtype the team should select about 3 cropping patterns to be evaluated. For some patterns on some landtypes these patterns may be the same.

c. Each cropping patterns should be replicated in at least 5 fields in total and in at least 4 fields per landtype.

The above research design should be modified as the team acquires more experience in the site. During the first year the number of patterns to be studied may be higher than 3 per landtype, so that the number of replications may need to be reduced to at least 4 in total and at least 3 per landtype. During the second year the number of patterns can be reduced and the number of replications can be increased to at least 5 in total and at least 4 per landtype. During the third year the team should have focused in on the most promising cropping patterns. This will allow them to further increase the number of replications per pattern to at least 6 in total and at least 4 per landtype (Table 3). It is recommended that the research team manage from 40 to 50 cropping pattern fields.

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*Subsequent committee discussions indicated that this site may need to be reduced where field sites are small. For extremely small field sites, operations may need to be measured over several fields to obtain accurate time estimates.

Analysis of cropping pattern trials involves the analysis of agronomic and economic performance of the patterns within the landtypes. To compare pattern performance simple T-tests for significance of difference may be used. By combining patterns in different groups within and across landtypes several comparisons can be made, giving the researcher a feel for the statistical significance of the differences found. Important criteria for evaluation of pattern performance is the size of the variation in yields and economic performance of each of the component crops and the total pattern. A close study of means and standard deviations for these alternative ways of grouping the results of pattern trials provides much insight.

Researchers may be interested in comparing the productivity of the landtypes they have selected. This can be done by evaluating the combined performance of all cropping patterns tested within each of the landtypes. It is probably better to compare the productivity and variance in productivity of the best performing pattern for each landtype as a measure of the cropping potential of that landtype.

An important analysis of cropping patterns is to compare the performance of the same crop in different patterns. The "same crop" in this context means that it is established in the same way and at about the same time in the cropping season, but it can be preceded or followed by a different crop and can thus be part of different cropping patterns. It is useful to pull together the results for each of these crops and compare them. This will allow a more valid comparison of the effect of landtypes and previous crops on the performance of the crop under evaluation.

The major contribution of cropping pattern trials is the in-depth analysis of environment by technology interactions. This analysis requires researchers to associate differences in crop performance with measured site variables, both land and climate related. This will be discussed as part of the Collaborative Cropping Pattern Monitoring project.

3. Superimposed trials for component technology evaluation

Superimposed trials are used to evaluate performance of the component technology assigned to the cropping pattern against alternative formulations while the pattern is managed by farmers. It should also give the team a measure of spatial variability in component technology performance and in the response to inputs when managed by the farmer. The alternative component technology should be over and above that used by the pattern.[2/] At times several alternatives (levels or sources, methods, etc.) may be compared.

[2/] To make the alternative levels lower than that specified for the pattern would require complete research management of the area of the superimposed trials. This aspect should be discussed by the Working Group, but I consider that input levels in the cropping patterns should be sufficiently low (economic considerations) to make lowering these levels not an attractive research design.

The number of superimposed trials and treatment is limited by the number of cropping patterns tested; and as the main objective of the superimposed trials is to evaluate the adequacy of component technology used in the pattern trial, it is felt that these trials should follow a standard format that allows an evaluation of all major management components that involve cash or sizeable labor inputs.

For the design of superimposed trials the following guidelines are suggested:

a. Select 2 to 4 component technology factors that strongly influence the performance of the cropping pattern. In this selection thought should be given to the cost of the component. Of particular interest are components that carry a high cash or labor cost. The factors to be studied can compare a combination of inputs, such as no insect control (P) vs. insect control (consisting of several activities during the crop seasons) (A). They may also compare single action inputs such as the insect control recommended for the pattern (P) vs. the insect control recommended for the pattern + an additional prophylactic control of head worms five days after flowering time (A). The factors of most interest will depend on the crop and pattern involved and on the land qualities considered. Some teams may want to superimpose 2 levels of a single factor, e.g. Nitrogen fertilizer rates because other factors appear less important when considering results of previous research at the site.

b. Identify the pattern level of each of these factors. It is suggested that this level be close to a low input level approximating that normally used by farmers in the region in similar situations, but sufficiently high to guarantee adequate production. For example, in cases where farmers do not use any nitrogen fertilizer on their rice, the cropping pattern level for nitrogen should not be 0, neither should it be 120 kg/ha. In most rainfed situations, depending on soil qualities it should probably be between 40 and 60 kg/ha in the initial cropping pattern trials. In considering this the reader must recall that to achieve superimposition and thereby farmers management of the basic pattern treatment, superimposed treatments often to be over and above that applied in the pattern. To compare the pattern treatment to a lower input treatment may require research management of superimposed trials. In this sense, the check, if included for economic analysis, is to be excluded from the rest of the cropping pattern treatment.

c. Identify the alternative level for the management component selected to be included in the test. Superimposed trials should include treatments comparing the pattern treatment (P) to treatments of a higher level of each of the important components -- weed control, insect control, fertilization, variety (where applicable or possible)* that would approach a prejudged optimum management. In this way additional returns obtained from increasing input levels for each of these factors beyond the cropping

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* Committee discussions and working group reactions indicated that varieties can best be studied in small plot trials at the same time and with the same inputs as the cropping pattern trials.

pattern level can be used as a criteria for considering a future increase in the level of that management component. In the above example, the team might want to evaluate 90 kg/ha of N as an alternative recommendation. Similarly it might want to add an additional prophylactic insect control treatment over and above that specified for the cropping pattern.

Figure 2 shows a proposed field plan for superimposed trials for the first crop and the second crop of a cropping pattern. Table 4 and 5 show the treatments and analysis of variance for the 2-, 3-, 4- and 5-factor designs proposed. These employ a partially replicated design in which the cropping pattern treatment (PPP) is replicated by taking two random yield samples from the pattern trial that are of similar size to those of the superimposed treatment plots. The alternative treatments (AAA), (which would be the highest input treatments) and a random other treatments (not the check) are replicated in the strip of superimposed plots.

Examples of the type of pattern treatments and alternative treatments are provided in Table 6. These treatments have been combined in example treatment desings for some 3-, 4-, and 5-"factor" superimposed trials (Table 7). Trials 2, 3, and 4 of Table 7 include more than one alternative for fertilization, insect control, and weed control.*

Because plot size of on-farm research trials should be larger than that of research station trials (Gomez, 1976), the following plot sizes are suggested:

- For rice (DSR, WSR, or TPR) 4 x 6 m
- For corn 6 x 8 m
- For sorghum 5 x 8 m
- For mungbean, cowpea, soybean 4 x 6 m

These are minimum plot sizes and depending on the size of the field in which the pattern trial is conducted and the special requirements for superimposed treatments (See Litsinger, 1976), these plot sizes may be increased.

For a given site, field sizes tend to be in a defined range and the research team can select their plot size and number of factors to be included in the superimposed trials accordingly.

Analysis of superimposed trials. Replication of some of the superimposed treatments within the field and the replication of trials across at least four cropping patterns allows the estimation of a reasonably pure error term from the analysis of variance (Table 5). This allows an F-test for the treatment x field interaction using the mean square ratio "TF/E". Where this test is significant the superimposed treatments gave different results in one or more of the different fields. Careful

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* These examples include a check treatment, which most working group members and the committee felt should not be recommended.

inspection of field characteristics and results of pattern monitoring may reveal reasons for these differences. At times a field may not belong to the landtype it was thought to fit into. Results from such fields can be recombined with those from other landtypes only if field description or plot monitoring results warrant this. Although strong TxF interactions may indicate that the landtype is poorly defined, most TxF interactions will arise from spatial variations for weed control and fertility factors caused by current or recent management and for insect control caused by differences in pest incidence. Re-evaluation of the definition of the landtype and the ways determinants changed from field to field to cause site differences, may, however, improve the land classification.

Where a significant treatment by field interaction exists and no valid regrouping is evident, the overall effect of treatments, averaged over all fields needs to be evaluated by the F-test: T/TxF. Where treatment by field interaction is not significant, the researcher may combine the TxF and Error sums of squares and their associated degress of freedom for testing the effect of treatments and fields.

The economic analysis of superimposed trials will evaluate returns from the recommended cropping pattern levels (PPP) from the difference in production and costs between PPP and 000. Economic analysis should evaluate the profitability of further increasing input levels for each of the factors studied by comparing the PPP treatments to APP, TAP, TTA, and AAA for the first, second, third, and all three technological components combined. Where farmers' reaction are positive and economic returns are sufficiently stable and above the average returns to cash and labor in the region, researchers should consider increasing the component technology specification for that factor for the crop and pattern studied.

More comprehensive analysis can compare responses of similar crops in different patterns or landtypes and evaluate if the component technology recommendation needs to be different for these or if it can be generalized (which is preferable from an extension point of view).

This design of superimposed trials will lead to an upward optimalization of component technology. It depends strongly on the initial specification of conservative (low) input levels for the pattern trials.

Evaluation of component technology for farmers' cropping pattern

The designs discussed for superimposed trials can be used to evaluate the adequacy of input levels used by farmers on existing cropping patterns. Where this is desired the treatment PPP in Table 4 and Figure 2 becomes the farmers' treatment and the treatment AAA becomes an alternative, higher input treatment. Where available, this treatment can be the "recommended" treatment for the site. Normally, landtype or cropping pattern conditioned recommendations are not available, in which case the research team may need to use site description or site research results

to estimate optimum input levels. These should be higher than those employed by farmers, but must satisfy economic criteria when input costs are evaluated against their probable effect on production (See Fourth Cropping Systems Working Group Report pp. 36a to 36c).

SUMMARY

This paper discusses the design of site related research. It covers the testing of cropping pattern trials and the evaluation of component technology. The use of superimposed trials, in combination with cropping pattern tests is discussed in detail. While a proposal is made for the use of similar designs for such tests, the type of factors to be studied will depend on the characteristics and previous research at the site.

The research design proposed ties cropping pattern trials, on-farm research managed trials, and superimposed trials together. Each type of experiment is used for different purposes, yet their results can be compared due to the commonality of the cropping pattern treatment. The design for superimposed trials allow an upward approximation of the best management package for the pattern, while it discourages the inclusion of input levels that have not been proven to be of benefit.

Committee: H. Zandstra
P. Hobbs
H. Manzano

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Table 1. Insect control for premonsoon greencorn and sorghum after rice for Pangasinan, Crop year 1978-79.

Prophylactic applications	Corrective applications
Premsonsoon Greencorn	
Seed treatment: 2% wt/wt Furadan 50 DB for ants and corn seedling maggot (Caution: Be careful and do not smoke while planting, wash hands frequently).	None
Sorghum	
None	Visit the fields frequently during heading. If 1 corn earworm larva per 2 plants is seen, spray Sevin 85 WP (1.0 kg a.i./ha)

Table 2. Recommended weed control practices for cropping patterns, Pangasinan, 1977-78.

Crop	Weed control methods	Rate (kg ai/ha)	Time of application
Corn (before rice)	Hilling-up, 2 passes	-	3 WAE[a] or just after fertilizer topdressing
Dry seeded rice	Butachlor followed by one hand weeding	2.0	Immediately if soil is moist, or if soil is dry, after germinating rain followed by "as needed"[b]
Wet-seeded rice	Well puddled seedbed. If there is standing water - no weeding; otherwise, spot weeding.	-	As needed
Transplanted rice	Well puddled seedbed. If there is standing water - no weeding; otherwise, spot weeding.	-	As needed
Upland crop			
Field not plowed	Paraquat to be applied if 50% plant cover at time of crop establishment; otherwise, no weed control.	0.75	Prior to furrowing
Field plowed	Mungbeans and cowpeas - no weeding	-	
	Sorghum - interrow cultivation	-	to 4 WAE

a/ WAE - weeks after emergence

b/ Refers to manual weeding or spotweeding as needed

Table 3. Year to year variation in the design of cropping pattern trials reflecting trend towards reduced number of patterns and increased number of replications.

Land type	Pattern 1	2	3	4	5	6	7	Total
				YEAR 1				
1			3	4	3	4 a/		14
2	3	4	3				3	13
3	3		3		3		3	12
Total	6	4	9	4	6	4	6	39

Land type	Pattern 1	2	3	4	8	Total
			YEAR 2			
1			4	5	4	13
2	5	4	4			13
3		4	4		4	12
Total	5	8	12	5	8	38

Land type	Pattern 2	3	4	8	Total
		YEAR 3			
1		4	6	4	14
2	6	4			10
3	6	4		4	14
Total	12	12	6	8	38

a/ Number of replications (fields) of pattern 6 in landtype 1.

Table 4. Proposed treatments for the partially replicated superimposed trial design.

Treatment number	Number of factors[a] 2	3	4	5
1	PP	PPP	PPPP	PPPPP
2	AA	AAA	AAAA	AAAAA
3	OO	OOO	OOOO	OOOOO *
4	PA	PPA	PPPA	PPPPA
5	AP	PAP	PPAP	PPPAP
6	PP	APP	PAPP	PPAPP
7	AA	PPP	APPP	PAPPP
8	AP[c]	AAA	PPPP	APPPP
9		PPA[c]	AAAA	PPPPP [b]
10			PPAP[c]	AAAAA
11				PAPPP[c]

[a] Can be factors (f) or levels (l) so that $N = \sum_i f_i x\ l_i$

[b] Treatments below this line are replicated

[c] Randomly selected treatment, excluding treatments 1, 2, and 3.

* Committee and working group discussions indicated that the inclusion of this check treatment is not generally desirable.

Table 5. Analysis of variance of proposed superimposed trials, assuming four and five replications (Fields) of the cropping pattern trial.

Source	Degrees of freedom				Mean square
	2-factor	3-factor	4-factor	5-factor	
	Analysis of variance table for 4 replications				
Total	32	36	40	44	
Mean	1	1	1	1	
Fields (F)	3	3	3	3	F
Treatments (T)	4	5	6	7	T
T x F	12	15	18	21	TF
Error	12	12	12	12	E
	Analysis of variance table for 5 replications				
Total	40	45	50	55	
Mean	1	1	1	1	
Fields	4	4	4	4	F
Treatments (T)	4	5	6	7	T
T x F	16	20	24	28	TF
Error	15	15	15	15	E

Table 6. Examples of treatments (factors) for inclusion in superimposed trials.

	Factor	Level for that factor (all others = P	
		P	A[a]
1.	Insect control (sorghum after rice)	None	Complete (2 actions)
2.	Insect control (DSR rice bug)	None	Spray Sevin 85 WP at 5 DAF[b] (0.75 kg a.i./ha)
3.	Insect control (DSR)	0.5-kg a.i./ha BARADAN 3G basal in furrows	P3 + Sevin at 5 DAF
4.	Fertility (DSR)[c]	30-30-0 basal 30-0-0 PI	30-30-0 basal 60-0-0 PI
5.	Fertility (DSR)	30-30-30 basal 60-0-0 PI	30-30-0 basal 90-0-0 PI
6.	Fertility (DSR)	30-30-0 basal 30-0-0 PI	30-30-30 basal 60-0-0 PI
7.	Fertility (DSR)	30-30-0 basal 30-0-0 PI	30-30-30 basal 30-0-0 PI
8.	Weed control (DSR)	1 handweeding	Butachlor 2 kg a.i./ha + 1 handweeding
9.	Weed control (DSR)	1 handweeding	Butachlor + interrow cult. + 1 handweeding
10.	Weed control (DSR)	1 handweeding	Interrow cult. + 1 handweeding
11.	Weed con-rol (DSR)	Butachlor + 1 handweeding	Butachlor + 1 hand-weeding + 1 spotweeding

a/ Alternative treatments must be such that they can be obtained by applying additional inputs (during additional operations if need be) to those applied to the pattern treatment (P).

b/ Days after flowering

c/ Seeded in dry or moist soil or "dry seeded rice"

Table 7. Examples of superimposed treatment designs for a dry seeded rice crop using treatments listed in Table 6.

Trial no.		Factor 1	2	3	4	5
1	Pattern treatment	P1	P4	P8[a/]		
	Alterantive levels	A1	A6	A8	b/	
2	Pattern treatment	P3	P4	P11	P4	
	Alternative levels	A3	A4	A11	A5	c/
3	Pattern treatment	P2	P2	P2	P4	P4
	Alternative levels	A2	P3	A3	A4	P5[d/]
4	Pattern treatment	P3	A4	P8	P8	P8
	Alternative levels	A3	A5	A8	A10	A9[e/]

a/ P8 refers to column P and row 8 in Table 6.

b/ This is a simple 3-"factor" trial that evaluates increased inputs in Insecticides. Nitrogen (additional 30 kg N/ha at PI) and weed control (use of herbicide).

c/ Factor 4 in this trial compares an additional fertilization alternative

d/ This trial compares the pattern management against three insect control alternatives and two fertilization alternatives

e/ This trial already has a high input level for the pattern. It evaluates further additions to insect control (1 alternative), fertility (1 alternative) and weed control (3 alternatives in factorial combination with pattern level).

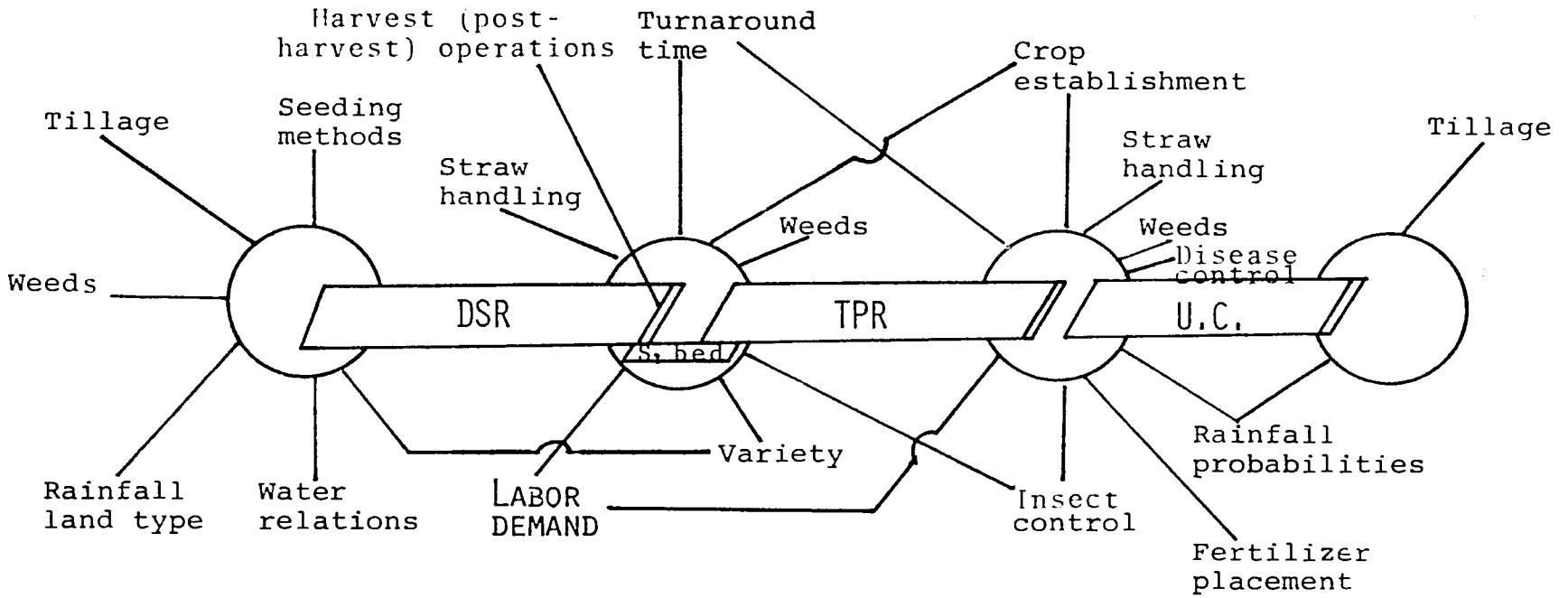

Figure 1. To assign component technology to a pattern requires a careful selection from many alternatives.

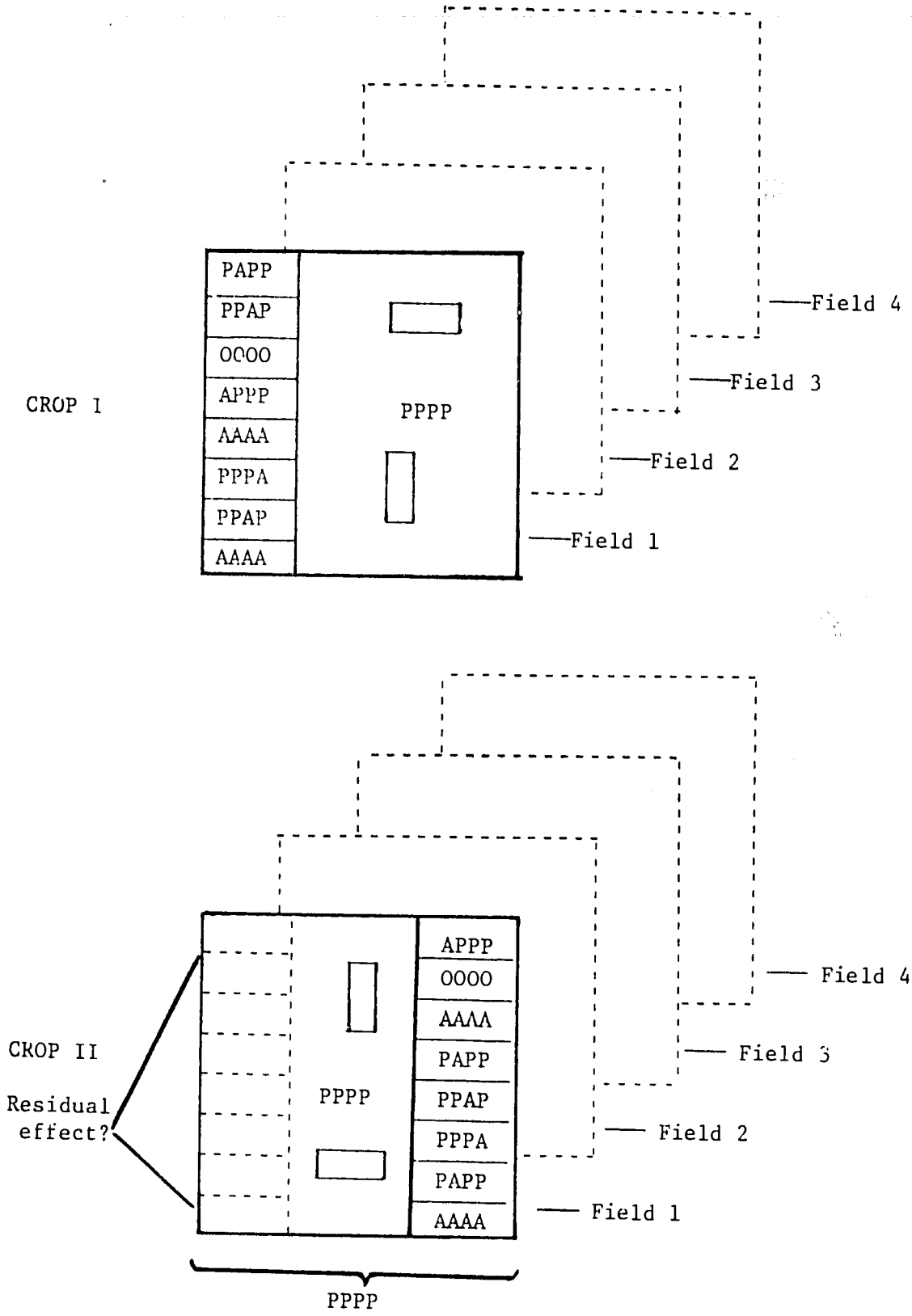

Figure 2. Proposed partially replicated design of superimposed trials for use in the evaluation of component technology used in cropping pattern trials. Example of 4-factor trial.

LENGTH OF TIME REQUIRED IN A RESEARCH SITE

A similar topic was discussed during the Fifth Working Group meeting held at Bangladesh. We were not sure then as to what would be the exact period required to operate cropping system (CS) research activity at each site. However it was suggested that possibly three years may be necessary (I). Deliberation on length of time required in a research site was made again during the present meeting because by now we have country programs operating for various duration and we can learn from new experience.

In this connection each program leader and other members cited examples of their program and participated in discussion. The general consensus was that it would be difficult for individual or a group of individuals to determine as to what would be the length of time required on each site. Countries differ in terms of (a) technology development ie. recommendation are available or are yet to be worked out (b) ease of interaction with the farmers which depends on factors like their education level, transport and communcation facilities (c) availability of trained man power and fund to carry out the program; to mention some major variables. These factors may also differ within the country from site to site. Based on combination of factors length of time required in a research site may be categorized as following:

1. One to two years - Site variables are relatively well understood; technology tested is found to be very successful and farmers are ready to adopt it. As an example Dr. Hoque mentioned that technology tested in irrigated area in one of Bangladesh site could be readily extended based on one year experience.

2. Three to four years - Technology needs repeated testing for verification of performance and stability of patterns; first year work may involve site description, seeting up site organization (recruitment of personnels, office establishment, interaction with farmers), nd preliminary testing of patterns. Some members remarked that it may take two years to understand the problem.

3. More than four years - In addition to development of technology for the site concerned other objectives are (a) development and refinement of research methodologies, (b) training of personnels, (c) testing newer technologies. The IRRI cropping system program has those objectives and is contemplating to run some of its site program for several years. Each country program may find it desirable to operate one site for long duration specially for training purpose. Such site need to be close to the headquarter.

4. More than four years - in addition to development of technology for the site concerned other objectives are (a) development and refinement of research methodologies, (b) training of personnels, (c) teasing newer technologies. The IRRI cropping systems program has those objectives and is contemplating to run some of its site program for several years. Each country program may find it desirable to operate one site for long duration specially for training purpose. Such site need to be close to the headquarters.

5. Indefinite period: some programs may be essentially permanent as the objectives are to determine changes in systems over time, an continously feed information back to appropriate authorities who can make necessary adjustments. The Mahaweli program in Sri Lanka is be set up for this.

It is felt that phasing of cropping systems research activity at the site should be well tied with extenstion and production program. How this can be done need to be discussed separately.

Reference

Proceeding of the Fifth Cropping Systems Working Group Meeting February 15-22, 1977, Bangladesh. IRRI, Philippines.

Committee: S. Lohani
D. Chandrapanya
R. Tinsley

ANALYSIS OF DATA COLLECTED IN CROPPING PATTERN MONITORING

Although the in-depth analyses of pattern monitoring data undertaken will generally be site-conditioned, several basic summaries and cross-tabulations, should be of interest to all site staff. Data availability (number of observations and range of attributes) will of course indicate if an analysis is even worth undertaking. The analytical capability of each project (staff time allocable to analysis, staff familiarity with analytical methods, computational equipment available) will influence the analyses undertaken, as well as the analytical techniques used. The discussion here centers around the analyses of data collected on Cropping Pattern Monitoring Forms 1 to 4, which might be undertaken by the site researchers. The types of analyses have been divided into Agronomic and Economic for convenience of discussion.

It is strongly suggested that for analyses other than summaries, a scientific hypothesis be stated and that deductions from the hypotheses be expressed in terms of the data to be analyzed and the relationships expected to be found in the data. Given the few observations often available for many "within year, within complex, within pattern" comparisons, interpretations will be more convincing if several attributes behave the way the hypothesis suggests they should.

A. Agronomic

1a. Identification of agronomic production complexes. In many cases, production complexes will berather evident. Summarization of data from From 2 should provide a clear indication of how many fields fall in each complex. The frequencies of each class can be found by cross-classifying two or more variables found on Form 2. E.g., landscape type vs. surface soil pH. In some cases, the variables found in the section describing supplementary water and soils will require a preliminary classification to derive more useful groupings other than those based on a single variable. E.g., the information in the supplementary water section can be used to construct four classes: (1) No supplemental water, (2) Gravity supplemental water between June and Sept., (3) Gravity supplemental water beyond September, and (4) Gravity supplemental water between June and September, and beyond September. Similar information condensations can be used to classify soils, for example, into 9 possible units on the basis of (a) high, medium and low pH, and (b) fine, medium and coarse texture. The frequencies of units with coarse texture may be very low and therefore not of interest to the project. In some cases, complexes may be based on other than physical factors, e.g. farm size or distance to markets.

1b. Verification of identified complexes. To determine if the complexes constructed in a 1a behave differently, yield data from Form 3 either by crop or by pattern or both, can be examined against the perceived classes. An examination of other attributes, such as (1) average crop or

soil water status ratings over selected portions of the year and (2) dates of planting may also indicate differences between classes, if the classes have been designed to distinguish different water regimes (Form 4). If differences in pest complexes have been sought through the classification, the pest ratings from Form 3 should be examined against these complexes. Once "verified", a complex can be used to aggregate data for other agronomic and economic analyses and as a basis for pattern and component technology recommendations.

2. Comparisons of proposed patterns (Form 2) vs. actual patterns (Form 3), should suggest whether crops within patterns or whole patterns are adapted or adoptable. When frequent deviations occur, farm-cooperators may be signalling that (1) they do not have the resources or ability to meet the cultural requirements of the crop at this time of the year or (2) they do not expect sufficient returns from the crop (because of low market prices or low yields or both) to justify growing the crop. An examination of the rainfall distribution (Form 1), especially with respect to deviations from long term "normal" rainfall may help to support explanations of why some crops were not attempted by farmer-cooperators.

3. Three classes of preliminary summaries from Form 3 are suggested. These summaries would indicate the general level (mean) of yields, pest pressures and inputs, and the variability in the data (standard deviation).

a. Crop yields, by verified complex and by time of planting.

b. Pest rating (for each dominant insect, and for weeds at 15 DAE and 40 DAE), by time of planting, by method of planting (and by verified complex).

c. Material inputs by crop (fertilizer, insecticides, varieties, herbicides).

These summaries should provide the following information: mean yield and variation by complex, and the number of observations per complex. The information contained in preliminary summaries should be useful to those who wish to take the analyses a step further and examine such relationships as yield vs. field operations and material inputs, insect ratings vs. insecticides, weed ratings vs. yield, weed ratings vs. cultural practices, insect ratings, vs. time of insecticide application, etc. The selection of routine analyses to make will be highly dependent on environmental factors and on the number of observations and range of attributes per cell (within year, within complex, within pattern).

B. Economic

1. For each field a summary of Total Variable Costs (as material costs, pre-harvest labor hours, harvest and post-harvest labor hours) and Gross Returns (as production x price of each product), will lead to Net Returns (NR); i.e., GR-TVC = NR. The data from each field can be used to find average performance by patterns over verified complexes. The cost component (%) for major and/or critical inputs such as fertilizers, insecticides and

land preparation hours can be extracted to show where future research might be directed : reduce high costs or other constraints. The returns to cash outlays for material inputs and for man-hour (and power) inputs used in the pattern can be computed and compared to the average recurns to cash and labor of the pre-project patterns used by farmers. To judge the stability of cropping pattern performance, the standard deviations of GR and NR should be computed on the basis of the patterns grown in each verified complex.

2. Within each verified complex, patterns (or alternative crops) can be ranked from least TVC to highest TVC, and from this ranking, marginal returns computed as the ratio of additional output to additional input to show the returns to the additional inputs required to grow the more costly patterns with each verified complex.

3. On the bases of the marginal returns, average net returns and variability in net returns, and the average returns to material costs and labor inputs, researchers should be better able to state which patterns hold promising for further design modifications and additional testing.

Committee: R. Morris
D. Chandrapanya
S. Lohani

PLANS FOR CROPPING SYSTEMS CONFERENCE

Date : Nov. 19-22, 1979

Place : International Rice Research Institute, Los Baños, Laguna

No. of Participants : 70

No. of Observers : 10

Objectives:

1. To review results of cropping systems research in target areas at different stages of development for the Asian rice farmer.

2. To review and prepare plans for collaborative research among cropping systems scientists in the Asian Cropping Systems Network.

3. To determine future research direction for cropping systems in order to increase food production and the economic well being of the Asian small scale farmer.

4. To exchange information and ideas among cropping systems scientists in Asia.

TENTATIVE PROGRAM

Monday 19 November 1979

AM

* Welcome Address (15 minutes)
* Role of cropping systems in increasing food production and economic level being of farmers in the next 10 years (50 minutes)
* Lead paper on establishing upland crops in lowland rice areas under rainfed conditions (30 minutes)
* Individual paper on component technology research (each 20 minutes)

tillage	weed control
soil moisture & texture	varietal improvement
soil fertility & plant nutrition	entomology

PM * Papers on establishing different upland crops after lowland rice under rainfed conditions

corn and sorghum	other legumes
soybeans	wheat
mungbeans, blackgram and cowpea	sesame, sunflower and peanut

Tuesday 20 November 1979

AM * Paper on description of research sites in different countries (50 minutes each) - across site comparison

* Design of cropping patterns for farmers' field testing (30 minutes)

* Testing of cropping pattern in the network (20 minutes each) Indonesia and Thailand

PM * Continuation of testing of cropping pattern in the network (20 minutes each)

Nepal	Sri Lanka
Burma	Philippines
Malaysia	South Korea
India	Bangladesh

* Applied research and pilot production programs in Philippines and Indonesia

Wednesday 21 November 1979

AM Papers on Component Technology (separate session)

Group I Pest Control

Paper on weed and insect control experiments related to cropping systems research in countries involved in the Asian Cropping Systems Network.

Group II Varietal Improvement

* Lead paper on varietal improvement

* Individual papers on:

Corn	Root crops
Sorghum	Wheat
Soybeans	Cowpea and peanut
Mungbeans	Other legumes

Group III Cropping Systems Economics

* Lead paper on cropping systems economics

* Individual papers on cropping systems site related economic research

Philippines	Thailand
Indonesia	Malaysia
Sri Lanka	Burma
Nepal	Bangladesh

PM Group I Pest Control

* Review of data on collaborative work

* Plan collaborative research work

* Determine major problems for future research in country programs and at IRRI

Group II Varietal Improvement

* Review of data on varietal testing and screening

* Plans on varietal testing and screening

* Relationship between national programs and varietal improvement centers to satisfy the need of cropping systems

* Determine major problems for future research directions

Group III Cropping Systems Economics

* Review collaborative research on economics

* Plan collaborative research

* Determine future research directions

Group IV Cropping Pattern Testing and Monitoring

* Review and revise (if necessary) cropping pattern monitoring format

* Plan other collaborative research in cropping pattern testing

Group V Production Programs and Policy Decisions

Thursday 22 November 1979

AM Group reports on significant findings, collaborative research plans and future research directions

0830	Pest control
0900	Cropping systems economics
9030	Varietal testing
1000	Coffee Break
1030	Cropping pattern testing and monitoring
1100	Production programs and policy decisions
1130	Closing Remarks
1200	Lunch

PM D e p a r t u r e

Committee: V. Carangal

J. McIntosh

Y. H. Shin

VARIETAL SCREENING AND TESTING

Considering that crop improvement programs is an going concern in all member countries, and that these programs have been traditionally oriented to mono-crop upland culture, the primary task of this committee is to look into ways and means by which the cropping systems orientation of these breeding programs can be strengthened. Obviously, the committee strongly endorses the idea of incorporating the cropping systems objectives into existing breeding program rather than initiating new and separate breeding programs.

The committee recognized the significance of breeding lines derived from the screening program of the UPLB. The promising genotypes are distributed by IRRI to other national programs and these genotypes have not only satisfied some of the varietal needs for multiple cropping but also have encouraged national breeders to look more seriously into the unique need for special varieties adapted to multiple cropping. It should be emphasized, however, that the services for pre-screening being done by UPLB is to phase out by June 1982. By then the country program should be strong enough to produce their own varieties for multiple cropping. This means that we should double our efforts to encourage our regular national breeding program to pay special attention to the needs of multiple cropping.

While screening for varieties for the humid tropics of Asia is probably, adequately satisified by the work at Los Banos, it was again brought out that the requirement for the sub-tropical areas in the region such as, Bangladesh and Nepal, is not covered. Thus, there is a need for another location whose primary focus would be the colder areas of the region. In this regard, Dr. Arwooth of Thailand presented their work (see attached paper) and indicated his willingness to screen materials that will suit the colder parts of the region. While Northern Thailand may not be as cold as Bangladesh and Nepal, the availability of funds and personnel to pursue the work favors its choice. It is felt that if screening were to be conducted during the winter months of December and January, the outstanding materials will probably do as well in the colder climates of Bangladesh and Nepal.

The committee also reviewed the list of characters that varieties suited for multiple cropping must possess. This list was agreed upon in the 1977 meeting in Sri Lanka. The committee feels that the list was too general and too inclusive. Consequently, the list of character does not differ very much from those that are normally pursued by existing breeding programs. It was felt that the listing must be more judicious and must emphasize those characters that are unique to the requirements of intensive farming. These characters are: short maturity, shade tolerance, vigorous seedlings and drought tolerance.

<u>Committee:</u> A. Gomez

A. Nalampang

T. Saing

VARIETAL SCREENING FOR DEVELOPMENT OF CROPPING SYSTEMS PRECEDING AND FOLLOWING RAINFED LOWLAND RICE IN THAILAND

Arwooth Nalampang[1/]

Introduction

Thailand grows about 10 million hectares of rice, of which only 2 million is irrigated and the rest is rainfed and mostly rainfed lowland rice. Under non-irrigated conditions, the majority of the area grows only a single crop rice from August to December. An examination of long term climatic data indicates the possibility of growing upland crops before or after rainfed rice and in certain better endowed areas, both before and after rice.

In order to translate the possibility into reality, however, several other factors must be considered and some of the basic constraints removed. One of the more important consideration, which is the theme of the present paper, is the selection of crop species and within the species, the varieties which fit the physical environment, more importantly the climatic elements, soil moisture and fertility.

Till recently crops and varieties were chosen on the basis of their potential yield under ideal conditions during the major growing seasons of crops. There is no certainity that varieties so selected will also perform equaly well in the "off season". For example, earliness to escape drought, tolerance to cold weather, ability to emerge under none too ideal land preparation following rice (along with wet and probably reduced soil conditions) become extremely important criteria in the off-season but not in the major growing season.

The above consideration have led to varietal screening of upland crops under the off-seasons conditions preceding and following rainfed lowland rice.

Varietal Screening

This was initiated in 1978. Work on upland crop following rice[2/] was taken up at the Mae Jo Field Crop Experiment Station, Chiang Mai during the January to April season. The station is situated at 18° 8' N and 99° E. Mean values of climate parameters and the rainfall during 1977-78

[1/] Chief, Oil Crop Branch, Field Crop Division, Department of Agriculture, Bangkhen, Bangkok, Thailand.

[2/] The term rice in these paper readers to rainfed lowland rice, unless other wise stated.

are given in Table 1a. The soil is loamy sand in texture, medium in fertility and with a relatively high water table. Main crop of rice is harvested generally in December, after which the land remains fallow. Crops studied were soybean, peanut, mungbean, field bean, corn and sorghum. After a moderate land preparation follows harvest of rice, upland crops were sown in the first week of January. One flooding was given after planting to insure crop stand. Except for occasional rains, the crops were raised on residual soil moisture.

Crops preceding rice were studied at the Roi Et Field Crop Experiment Station (16° N and 103° 5' E). Climatic data were also given in Table 1b. The soil is sandy in texture, low in fertility with low water table. Planting of upland crops was done in April after the first heavy rain. Crops tested were soybean, mungbean, black gram and sesame. The main crop of rice in this area is taken up in August.

Results and Discussion

Soybean Germplasm Evaluation

At Mae Jo: Of the 958 lines tested only 889 survived till harvest. Two duration groups, one maturing within 85 days (116 lines) and the other of duration 86 to 100 days (139 lines) were carried over for further testing at Roi Et.

At Roi Et: In the duration group of 85 days or less planted on April 18, 3 lines matured in 73 days, 62 lines in 87 days and 33 lines within 100 days. Only those lines which matured in 73 and 87 days were truly early and photo-period insensitive.

Yield per plant (mean of 5 plants) was used as index of yield potential. Since SJ 4, the check, yielded 15.3 g/plant, lines yielding 16 g/plant or more were saved for the next season. Among the 62 lines that matured from 74 to 87 days, 19 lines yielded 16 to 20 g, 7 lines yielded 21 to 25 g and 3 lines 26 to 29.5 g per plant.

The second group (maturing within 100 days at Mae Jo) consisting of 139 lines were planted at Roi Et on May 18. The results showed that only 62 lines matured within 85 to 100 days and were considered as day length insensitivity. Based on weight per plant, there were 11 lines yielded between 16 to 20 g/plant, 12 lines between 21 to 25 g/plant, and 4 lines over 30 g/plant.

Performance of selected lines of soybean

Eighteen selected lines of advanced generation from different crosses were grown at Roi Et along with check, SJ 4, on April 18. Data are given in table II. It should be noted that lines RYTH 3 and RYTH 6 matured earlier and outyielded the check.

Peanut, mungbean and blackgram

Results of screening these three legumes seemed less promising than those on soybean for several reasons. Firstly, the presently recommended varieties had already been selected for earliness, drought tolerance and photo-period insensitivity. Secondly, mungbean and black gram are both sensitive to cool weather in January planting. Further more, both of these crops suffer from harvesting problems when planted in April due to rains in June.

727 entries from varietal collection of mungbean were tested at Mae Jo, along with Uthong 1, the standard, which matured in 65-70 days and yielded 5-8 g/plant (1-1.6 t/ha). Their performance is summarized as follows:

No. of entries	Durations (days)	Yield (g/plant)
Uthong 1	65-70	5-8
4	66	>5
68	71	only 8 entries gave >5
88	79-81	only 12 entries gave>5

It was decided not to study this material in April planting since day length in April is longer than in January, all of them would have considerably a longer duration than the standard which is not acceptable.

The collection of 132 entries of black gram proved to be more sensitive to low temperature as well as to photoperiod than the standard, Uthong 2, which matured in 85-100 days. Results obtained from May planting at Roi Et revealed that only 18 entries matured between 85 to 100 days and were saved for further study. As stated earlier, harvest of black gram during rainy season caused several problems in both of yield and seed quality.

All the 1979 peanut entries planted on January 4, and harvested on May 9. Two entries M10 and Moket grew vigorously. There was no perceptible difference in duration.

Field bean and sesame

Field bean (Phaseolus vulgare) is a new crop in Thailand. Twenty one entries were planted on January 4 and harvested in the later part of March. Most of the entries grew well. Since there is no definite objective to work for, the selection criteria are not clear.

Sesame is a crop suitable for preceding rice. April planting at Roi Et indicated that one black seed local variety matured about 85 days and yielded nearly 500 kilograms per hectare. W 52, a Japanese white seed variety, yielded about 800 kilograms within 75 days. It should be noted

that if planting were done earlier than this in order to escape heavy rain during harvest, the seeds yield and quality would be much better.

Corn and Sorghum

Data on two sets of corn and one set of sorghum entries grown at Mae Jo are given in Table 3, 4 and 5. It is noteworthy that yields as high as 3 to 4 t/ha of corn can be obtained from the off season crop. Performance of sorghum was also good.

Conclusion

Based on one year data, there is a definite possibility of growing several upland crops in the paddy fields preceding or following the main rice crop. The crop varieties would possess special characteristics such as earliness, photoperiod insensitivity and drought and cold tolerance in addition to other agronomic characters. Further work on varietal improvement for specific situations is urgently required to make the off season cropping safe, viable and remunerative. Besides the extra income obtained from new cropping systems, soil fertility could also be maintained, if not improved, by including legumes to the system.

Table 2. Performance of certain selected soybean lines grow at Roi Et Experiment Station.

Entries	Mature (days)	Plant height (cm)1/	Pods/ plant 2/	G. per 100 seeds 3/	G. of seed per plant 4/	Cal. yield ton/ha 5/
SJ 4	107	46.4	50.1	13.2	15.3	3.06
RYTH 3	84	36.4	84.4	13.5	16.3	3.26
RYTH 7	87	54.4	77.6	14.5	19.8	3.96
RYTH 8	98	47.1	72.6	12.1	15.4	3.08
RYTH 15	98	52.7	90.7	15.7	24.1	4.82
RYTH 17	98	45.1	108.3	11.7	16.4	3.28

Remarks: 1/) 2/) 3/) 4/) Taken from average of 5 plants

5/ Recommended population of 200,000 plant per hectare.

Table 1a. Amount of rainfall at Maejo Experiment Station.

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jan.	Jul.	Aug.
10 year ave.	209	95	27	26	19	8	19	72	197	120	175	273
77-78	271	146	-	40	31	12	1					

Table 1b. Amount of rainfall at Roi-et Experiment Station.

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jan.	Jul.	Aug.
10 year ave.	254	106	8	4	5	21	21	97	186	206	214	264
77-78					7	9	48	136	182	136	354	

Remarks: ———— indicates main rice crops.

---------- indicates off season crops.

Table 3. Mean grain yield and agronomic characteristics of corn tested at Maejo (Experiment 1) in 1978 dry season.

Entry No.	Pedigree	Origin	Grain yield at 15% mois. kg/rai	Grain yield at 15% mois. kg/ha	Relative to check	Days to silking (50%)	Height (cm) Plant	Height (cm) Ear	Lodging (%) Stalk	Lodging (%) Root	Ear Aspect	Ear/ plant	% moisture	Seed char.
6	Harapan + Medok - 52	CRIA	586	3660	117	56	167	13	16	12	2	0.9	17	[illegible]
25	Chainat 1801	CN 75 D	536	3350	107	58	182	15	6	3	2	0.9	25	[illegible]
22	Neb 3 + B - DMR_3	SW 77 D 70155	525	3280	105	59	145	14	2	1	2	0.9	18	[illegible]
15	Metro + Medok - 558	CRIA	507	3170	102	60	155	14	5	5	4	0.9	19	YOWF
5	Harapan + Medok - 18	CRIA	498	3110	100	56	179	14	11	15	2	0.9	17	OWYF
7	Harapan + Putih Nusa-68	CRIA	493	3080	99	56	169	14	12	14	2	0.9	20	WOYF
8	Harapan + Putik Nusa-77	CRIA	474	2960	95	56	171	14	14	13	2	0.9	18	YOPWSF
1	Harapan + Medok - 5	CRIA	472	2950	94	56	179	14	14	15	2	0.7	19	[illegible]
18	Bogor DMR - 11	CRIA	467	2920	93	56	167	13	11	7	2	0.9	18	WOYF
4	Harapan + Medok - 15	CRIA	466	2910	93	57	166	14	10	18	2	0.9	17	OYWF
20	H - DMR + Neb 1	SW 77D 70140	458	2860	92	61	173	15	6	10	2	0.8	17	OYWFS
14	Metro + Impa - inpa - 547	CRIA	451	2820	90	60	165	14	8	11	2	0.9	19	WYOF
24	T - DMR 6 + Neb 4	SW 77D 70212	445	2780	89	57	168	14	5	4	3	0.9	18	YWOF
19	Bogor DMR -12	CRIA	437	2730	87	57	165	14	13	10	2	0.9	17	WOYF
9	Harapan + Putik Nusa 79	CRIA	435	2720	87	63	164	13	9	12	2	0.8	19	WOYF
17	Metro + 1039 - 748	CRIA	427	2670	85	54	158	13	6	15	2	0.7	17	PYOF
11	BC_2 + Medok - 1034	CRIA	422	2640	84	58	153	13	10	9	2	1.0	19	[illegible]
23	Neb 3 + Neb 4	SW77D 70196	410	2560	82	58	154	13	5	2	4	0.7	22	YOSFF
12	Metro + Medok - 434	CRIA	408	2550	82	57	146	13	12	6	3	0.9	17	OYWF
3	Harapan + Medok - 13	CRIA	403	2520	81	57	150	13	16	15	2	0.8	19	WYOF

Table 3. (Cont'd)

Entry No.	Pedigree	Origin	Grain yield at 15% mois.		Relative to check	Days to silking (50%)	Height (cm)		Lodging (%)		Ear Aspect	Ear/ plant	% moisture	Seed
			kg/rai	kg/ha			Plant	Ear	Stalk	Root				
2	Harapan + Medok - 8	CRIA	398	2490	80	56	163	13	8	15	2	0.8	18	WOYF
10	RC_2 + Medok - 1019	CRIA	394	2460	79	57	161	13	12	7	2	0.9	17	OYDF
21	B-DMR 3 + Neb 1	SW 77D 70142	362	2260	72	56	138	14	6	9	3	0.8	20	YOYSF
16	Metro = Genj Warangan-698	CRIA	277	1730	55	61	169	14	4	10	3	0.6	32	OYF
13	Metro + Impan - inpa - 545	CRIA	258	1610	52	59	158	14	2	11	3	0.5	31	OYF
26	Suwan 1	TF 76	499	3120	100	61	167	14	4	4	2	0.8	24	OYFP
	Mean		443	2769										
	L.S.D. (.05)		128	800										
	C.V. (%)		20.0											

Table 4. Mean grain yield and agronomic characteristics of corn tested at Maejo (Experiment 2) in 1978 dry season.

Entry No.	Pedigree	Origin	Grain yield at 15% mois. kg/rai	Grain yield at 15% mois. kg/ha	Relative to check	Days to silking (50%)	Height (cm) Plant	Height (cm) Ear	Lodging (%) Stalk	Lodging (%) Root	Ear Aspect	Ear/ plant	% moisture	Seed char.
10	Early Thai Comp. #1	IRRI	776	4850	112	58	196	14	11	26	1	1.2	22	OYWF
13	Phil. DMR Comp. #2	IRRI	752	4700	108	55	206	14	9	17	1	1.1	21	WOYF
12	Phil. DMR Comp. #1	IRRI	709	4430	102	55	227	14	9	17	2	1.0	19	WOYF
6	Indonesian Early DMR + TC#1 DMR(s) C_3F_1	IRRI	707	4420	102	52	177	13	12	9	2	1.1	19	OYWF
28	T-O_2 Comp 3 + Neb 5	SW77D 70209	672	4200	97	59	186	15	12	30	2	1.0	20	PYOWSP
16	Early DMR Comp. 1	IRRI	659	4120	95	55	145	14	7	39	2	1.0	20	YOWF
8	South Asian Pop II + SW1 F_3	IRRI	646	4040	93	62	197	15	3	27	1	0.9	24	YOF
5	SW1 DMR Source 4	IRRI	640	4000	92	52	188	14	8	25	2	1.0	18	WYOPF
20	Prolific DMR Comp. 1	IRRI	630	3940	91	59	197	14	16	39	1	1.1	20	WYOF
3	Suwan DMR Source 1	IRRI	622	3890	90	60	183	14	10	28	2	0.9	22	WOYF
15	TC#1 (Thai) + Early Phil	IRRI	621	3880	87	57	199	15	3	28	2	0.8	22	WYOF
30	Chainat 1801	CN 75D	602	3760	87	59	163	15	11	42	2	0.9	22	PYOF
4	SW 1 (S) C_4	IRRI	592	3890	85	63	179	14	12	28	1	0.8	24	WYOF
19	CBWR DMR Comp II	IRRI	579	3620	83	57	185	14	9	23	2	1.0	23	WYOF
17	Early DMR Comp II	IRRI	576	3600	83	53	183	14	14	44	2	1.0	18	YWODF
9	South Asian Pop III + SW1 F_3	IRRI	570	3560	82	62	192	14	2	41	1	1.1	24	OYF

Table 4. (Cont'd).

Entry No.	Pedigree	Origin	Grain yield at 15% mois. kg/rai	Grain yield at 15% mois. kg/ ha	Relative to check	Days to silking (50%)	Height (cm) Plant	Height (cm) Ear	Lodging (%) Stalk	Lodging (%) Root	Ear Aspect	Ear/ plant	% moisture	Seed char.
25	T-DMR 6 + Neb 4	SW 77D 70212	555	3470	80	53	193	14	8	14	3	0.8	18	YOWF
2	TC #1 Medok	IRRI	546	3410	79	55	191	14	6	49	1	0.9	18	OYDF
27	Neb 2 + Neb 4	SW 77D 70196	546	3410	79	55	185	15	16	58	3	0.9	21	OYSF
18	CBWR Dmr Comp 1	IRRI	538	3360	77	59	194	14	17	33	2	0.9	23	YOWF
11	TC#1 DMR + Penjalinan F_3	IRRI	509	3180	73	46	183	15	24	38	2	1.0	19	WYOF
26	G-Kretek + B - DMR 3	SW 77D 70177	494	3090	71	51	171	13	14	29	3	1.0	15	WYOSF
23	Neb 3 + B - DMR 3	70155	490	3060	71	59	167	15	4	3	2	0.8	23	WYOSF
22	B - DMR 3 + Neb 1	70142	477	2980	69	52	174	14	10	15	2	0.8	19	YOWF
24	Neb 3 + Neb 4	70196	469	2930	67	68	170	15	8	10	3	0.8	23	YOWSF
29	T - DMR 6 + Neb 5	70210	430	2690	62	57	158	14	14	29	3	0.8	18	YOSF
1	TC#1 DMR Early(S) C_2	IRRI	416	2600	60	59	196	14	3	32	1	1.0	22	WYOF
21	Neb 3 + H-DMR	SW 77D 70153	400	2500	58	69	221	16	16	22	3	0.7	25	OYPF
7	South Asian Pop 1 + SW 1 F_3	IRRI	362	2260	52	57	183	14	2	30	2	1.2	23	OYWDF
14	Tinumbaga	IRRI	150	940	22	54	190	13	-	8	2	1.3	21	OYWF
31	Suwan 1	TF 76R	694	4340	100	63	181	14	5	36	1	0.9	26	YOWF
	Mean		562	3512										
	L.S.D. (.05)		136	850										
	C.V. (%)		15.0											

Table 5. Grain yield at 15% moisture content and other agronomic traits of sorghum tested at Maejo Field Crop Experiment Station (19°N) during the dry season of 1978.

Pedigree	Grain yield		Days to 50% flower	Height (cm)	Leaves per plant	Lodging (%)	Heads per plant	Rating 1/			Grain color
	kg/rai	kg/hectare						Seedling vigor	Insect resistance	Grain weathering	
CS 102	459	2,869	58	93	7	16	1.6	2.2	2.1	2.6	dark brown
D67-1	430	2,687	63	97	9	32	1.2	3.2	2.1	2.6	"
CS 99	417	2,606	60	94	8	15	1.3	3.5	2.0	2.5	light brown
CS 103	412	2,575	59	90	7	12	1.3	2.6	1.7	3.0	dark brown
UPLB-SG 5	409	2,556	62	92	9	8	1.4	3.1	1.9	1.7	light brown
IS-2940	409	2,556	59	112	9	21	1.2	2.2	1.9	1.6	"
CS 137	407	2,544	65	90	9	14	1.2	2.2	1.7	1.9	"
Cosor 3	399	2,494	60	91	8	3	1.2	3.5	1.7	3.4	"
CS 108	389	2,431	62	84	8	4	1.3	3.1	3.4	2.0	"
BPI-SOR 1	389	2,431	64	107	10	16	1.2	2.1	2.5	2.4	"
CS - 174	387	2,418	61	90	9	15	1.3	2.1	2.4	2.7	"
CS 120	356	2,225	63	91	9	9	1.1	3.1	2.2	2.4	"
D 67-4	295	1,844	63	90	8	29	1.1	2.5	1.6	2.4	"
ICRISAT 1419	289	1,806	82	100	12	12	1.3	2.1	1.0	4.0	white
498003	274	1,712	60	92	8	26	1.6	3.1	1.9	4.6	light brown
Hegari 122	258	1,612	60	117	10	41	1.0	3.0	2.5	5.0	white
TSS 7-5	208	1,300	90	108	11	6	1.2	2.6	1.0	3.0	yellow
ICRISAT 1359	197	1,231	79	87	13	19	1.2	1.7	1.6	4.2	yellow
Kokpra Hegari	104	650	61	96	8	6	1.7	2.7	2.1	3.5	white
LSD (.05)	154	962									
CV (%)	34										

1/ Rating: 1 = good and 5 = poor. Rainfalls on May 9 and 15, 1978 were 57 and 45 mm. Sorghum was flooded once at planting (January 9, 1978).

Date harvested, May 22, 1978. Plots were fertilized with N, P_2O_5 at 125 kilograms per hectare.

PERFORMANCE OF UPLAND CROP VARIETIES GROWN AFTER RICE IN IRRI AND THE PHILIPPINE CROPPING SYSTEMS OUTREACH SITES IN 1977-78

Highlights

Introduction

One of the collaborative research across the Asian cropping systems network is varietal evaluation of upland crops involved in the rice-based cropping systems. These crops are corn, sorghum, soybean, peanut, mungbean, cowpea and sweet potato in addition to rice. This testing provides national program with elite cultivars adapted for intensive cropping. Since IRRI has no mandate to work on the varietal improvement on the upland crops mentioned, IRRI is presently collaborating with the University of the Philippines at Los Banos (UPLB) and the Institute of Plant Breeding (IPB) to identify promising varieties or lines suitable for intensive cropping with emphasis on food crops grown after rice in lowland areas. UPLB is getting genetic materials for their screening from the international and regional centers, national programs and their own breeding program. The most promising entries in their screening program and outstanding varieties from national programs are then evaluated in replicated trials in different cropping systems research sites in the Asian Cropping Systems Network. In some countries evaluation is done in an experiment station near the research site. In the Philippines, IRRI in collaboration with UPLB and the Bureau of Plant Industry is conducting the trials in the IRRI farm and the three research sites in Cale, Tanauan, Batangas; Pao and Caaringayan, Manaoag, Pangasinan; and Oton and Tigbauan, Iloilo. The description of the cropping systems research site in Batangas, Pangasinan and Iloilo and the IRRI farm can be found in be 1976-77 report "On Varietal Performance Testing of Rice and Upland Crops in IRRI and the Philippine Cropping Systems Outreach Site".

This report will cover the varietal evaluation of upland crops in the IRRI farm and the three research sites in the Philippines, Batangas, Pangasinan and Iloilo. The other programs involved in the network will report their work separately.

Methods

Seeds for the varietal testing were increased at the IRRI farm and UPLB. The number of entries varies from crop to crop. Entries to be included are discussed between the varietal improvement group at UPLB, IPB and IRRI. Trials inthe cropping systems outreach sites were conducted in farmers' fields under the management of the research assistant. In some cases, trials were conducted in rented farmer's land. The design is simple randomized block design with 3 to 4 replications. One replication in each

trial didnot have any insect control to identify some variety that shows resistance to pest and diseases. The other replications have insect control. The cultural management of the trials was the same as the management of the cropping pattern trial in the site. Therefore, management will vary from site to site. The collection of data is uniform across the different site. Each set of trial has guidelines for collecting data to have a uniform data format for reporting. The trials were conducted under upland conditions following upland rice in IRRI and Batangas using high tillage. In Iloilo and Pangasinan, trials were conducted after harvesting of lowland rice both using zero and high tillage.

Results

Corn. There are 15 entries in the trial. Entries were from the breeding programs of UPLB and Kasetsart University in Thailand. The trials in IRRI and Batangas were affected by heavy rainfall few weeks after germination and drought later until harvesting. Thus, the yield levels were very low with 1.10-2.08 tons/ha in IRRI and 0.78-2.02 tons/ha in Batangas (both under upland conditions). When planted after lowland rice with zero tillage in Pangasinan and IRRI, the yield levels were even lower. The most promising entry in the upland trials was Indonesian Early DMR x TC#1 DMR(s) C_3F_1, a new entry from Thailand. The trial without insect control showed lower yields than those with insect control. There are few entries that performed well both with and without insect control.

Sorghum. Fourteen varieties and a hybrid sorghum were evaluated. The entries were from the UPLB breeding program and a hybrid from Pionner Seed Company. Inspite of heavy rains few weeks after germination and drought until maturity, yield of sorghum was higher than corn in IRRI and Batangas. The highest yielders under upland conditions were Pioneer Hybrid in IRRI (4.74 tons/ha) and CS-120 in Batangas (3.70 tons/ha). The yield level at zero tillage at IRRI was lower with CS 137 showing the highest yield. In Pangasinan the zero tillage trial showed high yield levels (2.30-4.08 tons/ha) than the high tillage trial (1.40-2.52 tons/ha). D67-4 is the most promising under zero tillage. The most promising entries in Iloilo under zero tillage were the Pioneer Hybrid and also D67-4.

Mungbeans. The performance of mungbeans under upland conditions at high tillage was very good inspite of heavy rains 3 weeks after germination and drought afterwards in IRRI and Batangas. Several varieties (CES U-1, Bhacti, and CES 55) were better than the newly recommended CES 1D-21. The highest yielder in Batangas was CES U-1 (1.86 tons/ha) and CES 1T-2 (1.59 tons/ha) in the IRRI farm.

Likewise yield levels at low and zero tillage conducted after lowland rice in Pangasinan and Iloilo were good but not in IRRI because of the heavy rains 3 weeks after germination. CES X-10 was the highest yielder in Pangasinan with 1.86 tons/ha, CES 55 in Iloilo with 1.24 tons/ha and CES 55 in IRRI with 0.84 ton/ha. The trials conducted after rice with high tillage in Pangasinan and Iloilo were also satisfactory with EG-MG 174-3 and CES X-10 giving the highest yield (1.49 and 1.47 tons/ha, respectively).

There were several varieties that showed tolerance to cercospora leaf spot and powdery mildew. The most tolerant were CES X-10, CES U-1, CES 1T-2 and CES 1D-21. The replication in each trial without insect control showed much lower yields than the replication with insect control indicating the importance of insect management in mungbeans.

Soybeans. There were 14 entries in the trial, mostly introduced varieties and varieties developed at UPLB. Like in previous years, yield levels were very low (less than 1.0 ton/ha). The highest yielder in Batangas conducted under upland conditions with high tillage was CES 70-68 (0.98 ton/ha) followed by Clark 63. Reduction in yield without insect control was not very much compared with mungbeans. When conducted after rice at high tillage in Pangasinan and Iloilo, Clark 63 (a recommended variety) was the best (0.59 and 0.41 ton/ha respectively). However, with zero tillage after lowland rice, the highest yielder was CES 70-68 in both locations (0.44 and 0.61 ton/ha). The reduction in yield without insect control was also not as much as in mungbeans.

Peanut. Fifteen peanut selections were evaluated in different sites. Among the three most promising varieties (M10, BPI P9 and Moket) in 1976-77 trial only M10 and Moket showed again very promising yields in Batangas, Pangasinan and Iloilo. A new entry, Dixie Giant was also the most promising with the hignest yield in IRRI (3.06 tons/ha) and among the top five entries in other locations. Yields were reduced in replication without insect control alchough it was not as much as in mungbeans.

Cowpea. There were 15 entries in the yield trial. Under upland conditions with high tillage the most promising in IRRI and Batangas was a new entry, TVx 66-2H (2.68 tons and 0.81 ton/ha, respectively). EG #2, the recommended variety was also outstanding in Batangas. Pelungga was the highest yielder with 1.84 tons/ha in Manaoag under low tillage which was 145% better than EG #2 followed by All Season (1.47 tons/ha). In Iloilo at zero tillage, PI-221731 was the most promising with 1.26 tons/ha. At high tillage in Pangasinan, TVu 15-2-1C, PI-221731 and Pelungga were the most promising. There were several new entries better than EG #2 in most locations.

The promising varieties under upland conditions are not outstanding when grown in lowland after rice. Yield levels of replication without insect control was very much lower than replication with insect control like in mungbeans indicating the need for insect control of present improved varieties.

Two international trials from IITA were also conducted in IRRI, the Uniform Cultivar Trial No.1 and No.2. Trial No.1 consist of indeterminate and No.2 determinate entries. There were 9 entries in Trial No.1 better than EG #3, the check variety. Vita 3 and Vita 1 were the highest yielders. In Trial No.2, all the entries (7) were better than V59-41, a recommended determinate variety.

Sweet potato. Fifteen entries were evaluated. The most promising under upland conditions in IRRI and Batagnas were Georgia Red, SP #45 and Karja 381. Yield levels were lower in Batangas (3.11-20.56 tons/ha) than IRRI (7.46-30.32 tons/ha) because of the long drought. BNAS 51 the highest yielder in both locations last year didnot perform well this year. Like last year the trials in Pangasinan had lower yields compared to the other sites. Karja 381, the most promising last year again showed good performance although the highest yielder was Bangued with 11.01 tons/ha. In Iloilo, Jewel had the highest yield (14.83 tons/ha) like last year. The other two promising entries were SP #45 and Georgia Red.

We again evaluated sweet potato at zero tillage by planting the cuttings right after harvesting lowland rice. One week after planting, rice straw was used as mulch. The most promising varieties were Karja 381, Georgia Red, SP #45, Bnasayon and BINAS 51. Karja 381 had the highest yield (20.56 tons/ha).

A COLLABORATIVE PROJECT IN ENTOMOLOGY FOR CROPPING SYSTEMS PROGRAMS

The role of entomology in cropping systems programs is to develop suitable insect control recommendations for each crop in the patterns tested at the various research sites. We stress the word, "suitable", as to effectively achieve this goal involves gathering information at the sites on technology performance and farmer behavior which at this stage is both an art and a science.

In this age where modern effective insecticides are readily available, entomologists have little difficulty in controlling pests, however, in cropping systems work we are most concerned that recommendations be developed which will be adopted by the farmers in each target area. Therefore suitable recommendations are defined as those which become adopted.

The challenge for entomologists in cropping systems work is to be able to quickly determine insect control regimes which will meet the farmers' requirements for adoptability.

A methodology to achieve this goal is being developed and will require the efforts of those in several disciplines - economists, sociologists, extension agents, agronomists - in order to complete. In order to test and more fully develop a methodology the involvement and comments of many cropping systems research teams will be indispensable - thus the need for a collaborative project within the Asian Cropping Systems Network.

We do not have all of the necessary information to know how to develop suitable recommendations at this stage in cropping systems work. However we have come a long way in knowing how to approach the problem and there are many things we can incorporate today as we strive to achieve our objective.

The following is an outline of the type of information needed in order to meet the requirements of adoptability following the cropping systems overall methodology of description, design, testing, and pre-production evaluation:

1. Determination of the need for insect control (description)

    a. Quantification of yield loss in economic terms

    b. Pinpointing target pests responsible for the yield loss through sampling

2. Understanding the target farmer (description)

    a. Quality and quantity of resources used in insect control on existing cropping patterns

    b. Finding out which insect control tactics farmers comprehend (chemical control, biocontrol, cultural control, host plant resistance)

c. Understanding farmers' constraints in adoption of technology

i. Sociological and cultural constraints

ii. Economic constraints of cash, power, and labor

iii. Management limitations in farmers' understanding of the technology

a. Pest recognition
b. Assessment of population levels (i.e., knowing when to apply technology)
c. Decision making between technologies
d. Knowing how to execute the technology effectively.

3. Assessment of the technology (design)

a. Reliance on proven technologies, (i.e., those that have been tested in the country, mostly at experiment stations, and form the basis of the national recommendations)

b. Selection of the most appropriate technology to test at the sites as determined from the results of the descriptive phase

4. Verification of the technology at the sites by researchers (testing)

a. Testing the technology on each crop under the conditions in which it is grown in actual cropping patterns on farmers' fields to determine environmental interactions

b. Testing the technology at the management level as determined by the other discipline team members

5. Evaluation of the farmers' performance in executing the technology (pre-production evaluation)

The framework outlined above is a further clarification of that developed earlier as presented to the Asian Cropping Systems Working Group (see Bandong et al, 1977; Litsinger, 1977; Litsinger et al, 1977, for its historical development to date).

This collaborative project focuses on a way to determine the need for insect control, which is the first step in the overall development of insect control recommendations. The procedure that we outline is simple and straightforward, requiring little data gathering on the part of the researchers. This meets the requirements of many national programs which often have problems of manpower. It is also flexible and can be modified for any crop.

Yield losses due to insects are highly site-specific and are a function of the pest complex, environment, and cropping patterns. Losses can occur during any or all crop growth stages, even on highly pest resistant varieties, if they exist. Quantification of yield loss by crop growth stage will result

in a more efficient use of insect control technologies, thus allowing more economical recommendations to be considered.

Of the insect control tactics available today, we rely mainly on insecticides, host plant resistance, and cultural control. Insect control through manipulation of natural enemies is many research man-years ahead of us.

For the purposes of this proposal and the methodology herein, we assume that appropriate insect resistant varieties will be utilized. We therefore focus on management decisions regarding insecticide usage and cultural controls which utilize scarce cash and labor resources.

Insect pest populations are highly dynamic and vary dramatically in time and space, making control efforts difficult. Insect control recommendations for a crop will not only vary from site to site but for each planting date within cropping patterns, even rice followed by rice. The three-year testing period for each site, which is normal for cropping systems programs, will be ample to determine the key pests which are likely occur. However one of the greatest dilemmas we face in crop protection entomology is that pest populations are bound to change in time in response to changes in crop production practices and the inadvertant introduction of new pests into an area. There is little we can do to prevent this, and the best we can do is to be aware of the possibilities and react quickly as the changes appear. Today we must develop recommendations based on current pest conditions, making them as economically attractive to farmers and stable as we know how.

A METHODOLOGY TO DEVELOP INSECT CONTROL RECOMMENDATIONS

In order to specify insect control recommendations for a site we need to know what level of technology farmers currently employ. Much of this information will be provided in the baseline survey and farmer record-keeping data compiled by the economics staff at the site. An analysis of this data provides information on insecticide usage in terms of chemicals; application, timing and frequency; and cash and labor inputs.

It would be desirable to study insect control practices in greater detail through special interviews with farmers to learn to their ability to recognize pests, their understanding of each control tactic, we might utilize, and to learn of their traditional methods of insect control. This has been done in the Philippines (Litsinger et al, 1978) and can be done elsewhere with a minimum effort and expense.

Results of these information gathering efforts will determine the level of resources we can expect farmers to employ and provide a basis from which to build. Recommendations need to dovetail with current farmer practices and management abilities if they are to be adopted.

We then want to know what resources to apply and when. To do this need to identify the pests at the site and determine the degree and time of yield loss for each crop in respective cropping patterns.

The objective of this proposal is to arrive at a common methodology to determine when insect control measures are to be applied to each crop. Data from insect population sampling during the crop growth will provide information on pest species so we will know what tactics to apply, based on experiment station results, and the resource capabilities of the particular set of farmers in question.

The methodology to determine when to apply insect control measures during the growth of the crop must involve as little data gathering as possible to meet the limitations of manpower, plot size, time at the site, and resource availability for research as well as concurrently allow for treatments which test actual recommendations.

The trials are performed on cropping patterns in farmers' field grown under recommended management practices by the research team. Because of the relatively large plot size necessary for insect work (50-100 sq m), treatments are replicated across farms. A minimum of four farms (replicates) is suggested, however 6 to 8 farms are best.

Insect pest populations will be monitored during the crop using recognized sampling procedures. The amount of effort expended here is in relation to manpower availability, but at least qualitative measurements can be taken.

Broad spectrum insecticides applied at high dosages are used as a tool to determine the impact of damage by eliminating insect pests as much as possible. Combinations of treatments covering the various plant growth stages enable us to isolate the yield loss for a given growth interval. The number of treatments involved is conditioned by the plant growth duration and variety of pest situations that one could expect. To be more reliable, it should be repeated for two to three years per crop at each location.

We will now elaborate on this methodology with examples from the Philippines, but it is highly adaptable to any crop, cropping pattern, or location.

We will use an example for transplanted rice.

From experience we expect insect pests to attack the following four growth stages: 1) seed bed (caseworm, armyworm, and whorl maggot), 2) transplanting to maximum tillering (caseworm, whorl maggot, stemborer dead hearts), 3) booting to panicle initiation (stem borer white heads and leaf folder), and 4) ripening (rice bug).

We will be using resistant varieties against brown planthopper and green leafhopper which are agronomically suited and recommended by the team. It is to be realized that if this resistance breaks down some years later, interim recommendations will be needed until new resistant varieties are introduced.

To identify yield loss for each of the four stages, as separate treatments, we omit insecticide protection during each of those stages, while providing control on the others. This subtractive approach gives a higher precision in interpretation of results than only having insecticide used during each stage because we expect yield loss during more than one growth interval.

In order to make the calculations to partition yield loss for each of the four growth intervals identified above we need two checks - 1) complete protection for all growth stages and 2) untreated.

The seventh treatment in this example is the recommended insect control practice for the cropping pattern. Inclusion of this treatment allows us to test the performance of the recommendation.

These treatments are outlined in Table 1. Once the yields have been taken for all plots we can calculate the yield loss for each growth stage. For example, say the complete protection (treatment 1) yielded 5 t/ha and the untreated control 2 t/ha. The treatment with the omission of seedbed protection yielded 4 t/ha. Calculations of the yield loss during the seedbed is (5-2)-(4-2) or 3-2 = 1 t/ha.

If rought rice is priced at ₱1.10/kg this yield loss translated to ₱1,000/ha. You might expec t farmers to spend money on chemicals for insect control to retrieve this loss if it is consistent. Therefore you can design insect control measures for this price range.

Examples for dry- and wet-seeded rice are presented in Tables 2 and 3 and merit no further comment.

Mungbean and cowpea provide an opportunity to vary the foregoing method slightly as there are only two basic growth stages, pre- and post-flowering. Insect pests are normally so severe that extensive damage is likely during both stages. Recommendations usually call for protection during both stages and the variation in design would determine the relative benefit from each. Accordingly the first treatment is complete protection at high rates (Table 4). Treatment 2 omits postflowering protection. The yield difference shows the potential gain from other pre- or postflowering protection. The same procedure is followed in treatments 3 and 4 except at recommended rates. Comparing similar treatments among recommended and high rates shows how well the recommendations are performing for each stage.

This becomes more clear if we follow an example using the treatment designations in Table 4. For example, say the yields from treatments 1 to 5 are 1.5 t/ha, 0.5 t/ha, 0.6 t/ha, 0.2 t/ha, and 0.1 t/ha, respectively. The potential benefit from insect control is 1.5-0.1 = 1.4 t/ha, partitioned 1.0 t/ha [(1.5-0.1) - (0.5-0.1)] and 0.4 t/ha (1.4-1.0), respectively, for pre- and postflowering protection, meaning that preflowering pests were very damaging. However the recommended control yielded only 0.6 t/ha which is 0.9 t/ha [(1.5-0.1) - (0.6-0.1)] less than the potential. If mungbean is priced at ₱4.50/kg, this translates into a substantial economic loss of

₱4050/ha. The yield loss partitioned within the recommended protection again showed a preponderance of preflowering insect pest damage. Preflowering losses were 0.4 t/ha [(0.6-0.1) - (0.2-0.1)] and postflowering losses were 0.1 t/ha [(0.6-0.1) - 0.4)]. We conclude therefore that the recommended protection is suboptimal and should be increased in the preflowering stage.

PROPOSAL

The foregoing methodology was formulated after four years of field experiments as an efficient means to determine appropriate insect control recommendations for cropping patterns utilizing current technology. Admittedly there still exists a large element of art rather than science involved in the decision making process governing what control tactics to use. There is no substitute for experience.

It is hoped that the method will save time and research funds through a more systematized approach for developing insect control recommendations. The methodology is flexible and can be used on any crop, and is meant to be adaptable to local pest situations.

It is recommended that the methodology as summarized in Tables 1 to 4 to be adopted in as many cropping systems programs as have the personnel to carry it out. The choice of insecticides to be used is left up to the specialists.

Future plans call for interdisciplinary monitoring tour to sites employing the methodology.

<u>Committee</u>: J. Litsinger

W. Fernando

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Table 1. Insect control treatments to partition yield loss for each growth stage of transplanted rice.

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1. Complete protection of all 4 growth stages.

   a. Seed bed (carbofuran granules mixed in seed bed at seeding a 0.5 kg ai/ha)

   b. Transplanting to maximum tillering (carbofuran granules soil incorporated during the last harrowing prior to transplanting at 1.5 kg ai/ha)

   c. Booting to panicle initiation (monocrotophos 45 and 55 DT sprays at 1.0 kg ai/ha)

   d. Ripening (carbaryl premilky stage and 7 days later - 2 sprays each 1.0 kg ai/ha

2. Omit 1a

3. Omit 1b

4. Omit 1c

5. Omit 1d

6. Recommended protection for cropping pattern

7. Untreated control

DT = days after transplanting

Table 2. Insect control treatments to partition yield loss for each growth stage of dry-seeded rice.

1. Complete protection
   a. Carbofuran granules mixed with fertilizer and placed in seed furrows each 0.5 kg ai/ha
   b. Maximum tillering to panicle initiation (monocrotophos - 2 sprays)
   c. Ripening (carbaryl pre-milky stage and 7 days later - 2 sprays each 1.0 kg ai/ha
2. Omit 1a
3. Omit 1b
4. Omit 1c
5. Recommended protection for cropping pattern
6. Untreated control

Table 3. Insect control treatments to partition yield loss for each growth stage of wet-seeded rice.

1. Complete protection
   a. Carbofuran granules soil incorporated at the last harrowing prior to seeding each 1.5 kg ai/ha (mix with fertilizer)
   b. Maximum tillering to panicle initiation (monocrotophos - 2 sprays)
   c. Ripening (carbaryl pre-milky stage and 7 days later - 2 sprays - each 1.0 kg ai/ha)
2. Omit 1a
3. Omit 1b
4. Omit 1c
5. Recommended protection for cropping pattern
6. Untreated control

Table 4. Insect control treatments to partition yield loss for each growth stage of cowpea and mungbean.

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1. Complete protection - pre- and post flowering

   High level

   a. Preflowering - Carbofuran seed treatment (1% wt/wt for Furadan 30 ST or 2% wt/wt for Furadan 75 WP) or Azodrin 0.5 kg ai/ha applied at 2 and 12 days after crop emergence (DE).
      Use precaution while applying Furadan, not to eat or smoke and wash hands afterwards. Phytotoxicity has been noticed for rates above 1% for Furadan 30 ST.

   b. Post flowering - Decis or Sumicidin sprays at 25 and 35 DE at 0.05 kg ai/ha.

2. Omit 1a

3. Recommended pre- and postflowering protection

4. Omit recommended preflowering protection

5. Untreated control

COLLABORATIVE RESEARCH: WEED CONTROL

The committee felt that there was no need to conduct collaborative weed research trials at the present time.

However, the committee recommends:

1. that a survey be done to determine which weeds occur in which crops at the time that they are grown in the cropping pattern. At the same time, weeds should be collected from the adjacent farmer's fields. Weeds should not be collected from crops grown at times which do not coincide with the pattern. If this is done, false impressions of the weeds and the problems that they create may be obtained.

   An attempt should be made to correlate the weeds that occur in the cropping pattern field to past cropping history, soil, climate, topography, etc. To make certain that the weeds are correctly identified the weeds should be collected in the flowering or fruiting stage or both and sent to some central location for identification.

   Within a country the weeds should be ranked in order of occurrence and importance. (The most commonly occurring weeds need not necessarily be the most important with respect to weed control).

2. that the crop losses caused by weeds be determined for each crop that is being grown in the various cropping patterns at the time that the crop occurs in the pattern. This should be determined in farmer's fields and not at experiment stations.

3. that all data pertaining to weed control trials in a particular country be collected and sent to IRRI for distribution to other countries in the cropping systems working group.

4. that once the information on important weeds and crop losses is obtained the possibility of collaborative weed research trials throughout the cropping systems network be considered again.

Recommendations from the working group:

1. that a paper on the effect of land preparation (and water accumulation) on weed growth in dry-seeded rice be written.

2. that a weed identification manual which is most suitable for use in the area be recommended.

3. that a recommendation be made on how to calculate man-hours spent weeding because as the number of man-hour spend in weeding increases the pay off to weeding decreases.

Committee: K. Moody

Z. Hoque

K. Kulkarni

COLLABORATIVE RESEARCH: CROPPING SYSTEMS ECONOMICS

The Economics Committee of the Working Group of the Asian Network for Cropping Systems Research met on April 26 and 27, and again on October 1 to 3, 1978. Discussions at the second session were a continuation of the first and this report covers them both.

Two documents were prepared as the basis for comparable studies at the outreach sites. They are, "Comparison of the Economic Performance of Cropping Pattern Trials and Farmers' Patterns," and a revision of "Information Schedule for Site Description and Crop Site Comparison." The former is included below, and the latter (unrevised) was reported in the December 1977 committee report. These two research outlines shall provide a basis for papers to be presented at a Cropping Systems Conference in 1979.

The following immediate activities and activity plans were decided:

a) That Ed Price would summarize and analyze the site descriptions, a preliminary draft of this analysis would be available for a working meeting of economists probably next April. Country coordinators and economists should anticipate a questionnaire from Ed Price before December to provide him with the data necessary for these site comparisons.

b) That Gordon Banta and John Flinn would analyze and review promising cropping patterns from an economic viewpoint in relation to various choice criteria. Banta would be responsible (as he regularly visits) for collecting the cropping pattern results from India, Sri Lanka, Bangladesh, and Thailand. Flinn would seek the data from the Philippines, Nepal, Malaysia, and through Rick Bernsten, Indonesia. As both Banta and Flinn will be in Trivandrum in November, they will liaise, review and standardize their approaches then. Line (a) they will have a first draft report for consideration by collaborating economist by April 1979.

c) As the coordinator of economic activities, Ed Price was urged to write to the collaborating coordinators/economists to advise them to your and our future short run activities.

<u>Committee</u>: E. Price
S. Mathema
G. Banta
Y. Hashim
J. Flinn

COMPARISON OF THE ECONOMIC PERFORMANCE OF CROPPING PATTERN TRIALS AND FARMERS' PATTERNS

Cropping systems researchers attempt to design and test experimental cropping patterns in a manner that leads eventually to the recommendation of new patterns having a good chance of adoption. At the testing stage realized performance of pattern trials on farmers' fields, under farmers' management with researcher supervision, is interpreted either for the purposes of recommendation or for redesign. Economic performance of cropping pattern trials has forward and backward linkages in the Design-Test-Introduce sequence.

As the research sequence is repeated each year at a given site, the mix of research effort gradually shifts from design and redesign activities to preproduction testing and introduction activities. Also the information mix used by researchers changes. If baseline surveys and other pre-design activities have been carried out, a large proportion of the information used at first concerns the performance of farmers' present cropping patterns, and the performance of pattern components elsewhere. The latter is derived from the literature and experience of researchers. Performance data on experimental patterns later becomes available and is heavily relied upon for redesign and making recommendation. Experimental patterns may be adopted by farmers, even before formal recommendation of the patterns, and this provides information on the post-adoption performance of new patterns under farmers' management.

The purpose of this note is to interpret information from cropping pattern trials and post-adoption performance of patterns in its backward linkage to re-design and its forward linkage to recommendations. Interpretation of post adoption data is beyond the scope of usual analyses of economic performance of cropping patterns in that the latter are usually conducted (or assumed to be conducted) before adoption. The problem seems relevant because unexpectedly substantial adoption of new patterns has taken place at Philippine sites within the first and second years of research. Farmers have copied new crops and techniques in pace with researchers' trials.

Furthermore, at least one national cropping systems program has included the most common farmers' patterns in their research design; that is, they have executed farmers patterns with farmers' management under researcher supervision. The "Cropping Pattern A," in field tests conducted by the Central Research Institute for Agriculture is the farmers' present pattern.

Recommendations from cropping pattern trials

To recommend a new cropping pattern researchers wish to be assured that the pattern will produce more than farmers' present patterns and that it will be accepted by farmers. Productivity is an easy test based

upon evidence in a cropping pattern trial. Acceptability is more difficult to ascertain, but a projection that new patterns will be more profitable than farmers' present patterns is considered a sufficient test of acceptability. Leaving aside the question of how to measure profitability, the projection of comparatively post-adoption profitability is usually based upon three items of information: (1) profitability of the cropping pattern trial, (2) profitability of farmers' present cropping patterns, and (3) expected changes in profitability brought about when the farmer manages the new pattern on his own, as compared to when he manages it under researcher supervision with input levels planned by researchers. Items (1) and (2) are respectively estimated from the trials and from farm records. If the new pattern has never actually been grown by farmers on their own, then item (3) must be estimated by looking at different patterns presently grown; or, assume a maximum possible rate of decline in profitability.

The latter course was chosen by the Working Group as a standard procedure. It is assumed that if the net profitability of a cropping pattern trial is 30 percent more profitable than farmers' present patterns, it will be accepted. Thirty percent of net profit is assumed to represent a maximum rate of decline in profitability when farmers adopt a pattern, pluw a margin sufficient to induce adoption.

In 1976-77, two experimental cropping patterns were tried on rainfed lowland with a shallow water table. The results are shown in tables 1 to 4, along with the performance of major patterns presently grown by farmers on this land type.

Farmers grew a combination of patterns, most commonly TPR (transplanted rice) followed by mungbeans. We can assume this is the best pattern to compare for the purposes of recommendation, partly because it is the most common pattern and partly because it is most similar to the rice-dryland crop combination in the experimental patterns. The researchers were trying to determine if an additional dryland crop could be grown before rice-mungbeans, or if mungbeans might be replaced by sorghum.

Rice-sorghum achieves a net return of 87% greater than farmers' rice-mung, and by established criteria it can be recommended for introduction to farmers. Green corn-rice-mungbeans performs more poorly, with a net profit below farmers rice mungbeans and therefore should not be recommended for introduction.

Other criteria for recommendation

Other criteria for recommendation have been suggested that may be considered as an alternative or supplement to the 30 percent rule.

Risk. Banta has suggested that the net profitability of an experimental pattern should be higher than the farmers' pattern expected to be replaced. But also, to account for risk, the net profitability must be sufficiently high to additionally pay the materials cost plus interest the previous year, in case of crop failure. In the case of rice-sorghum,

assuming 12% annual interest, its net profit should be 1766 pesos per hectare. This criteria is met. It is also met by the farmers' patterns, at least indicating no contradictory behavior by farmers.

Another treatment of risk is simply to repeat the trial additional years. After three years of trials, patterns can be recommended if they were profitable at least one year, but qualified by the percentage of years in three they met the 30% rule.

Returns to resources. In Iloilo, the rice-rice pattern trials have consistently shown both higher net returns and higher returns to labor and material costs. This never occurred in Pangasinan and may in fact be unusual. Incidentally, the rice-rice pattern is the one case in IRRI's experience of wide-scale early farmer adoption. Input levels on cropping pattern trials are typically higher than farmers' levels. If farmers are applying inputs precisely at the point where their marginal rates of return begin to decline, and researchers apply levels only slightly higher, it is feasible that average rates of return could be higher at the experimental level than at the farmers' level for similar technologies.

This condition is unusual, however. The Iloilo case likely results from more efficient technology. It is the general case that average rates of return at higher input levels will be lower. Therefore, it is not alarming that rates of return to resources on experimental patterns are lower than those of farmers' patterns.

Rates of return to resources should be regarded as a secondary criteria, after net returns criteria are met, to be interpreted with respect to farmers' resource availability and their values in alternative uses. The simpliest approach is to assume that farm labor and cash resources can be freely purchased and sold on village markets. In this case the secondary criteria requires that rates of return to resources should be higher than market rates. In Pangasinan labor can earn 1 peso per hour, and cash can be assumed to earn a maximum of 20 percent in a crop season. All farmers and experimental patterns meet these criteria.

If it is unreasonable to assume perfect markets for farm resources, researchers recommend patterns based upon their relative rates of return to labor and materials, compared to farmers' ralative resource availability. A farmer with large amounts of available labor compared to cash would theoretically prefer patterns offering relatively high rates of return to cash, and vise versa. However, this depends upon his alternative uses of cash and labor on the farm and their rates of return in those activities.

A more rigorous test for acceptable returns to resources would require an analysis of all farm activities using a technique such as linear programming. This approach is now being tried at IRRI with the objective of determining how effective are our simpler tests. It is being tried at the cropping pattern trials in Lampung, Indonesia as well.

Redesign based upon cropping pattern trials

Researchers may wish to redesign patterns that appear unprofitable in order to improve their economic performance. The same may be true of profitable patterns in order to better assure their acceptance. Improvement of pattern performance can be often accomplished by making adjustments in input applications. Redundant or low productive inputs may be evident from either relatively high absolute levels of input use compared to other experimental patterns and farmers' patterns on the same land class. Relatively low rates of returns to a resource may also indicate downward adjustments in the resource would improve performance.

Comparison of the performance of a pattern across land classes may reveal on what land class the pattern produces best and where input requirements are lower or greater. However, as the research objective is to find recommendable patterns for a given land class the information is best interpreted as an aide to improving a pattern's performance. For example, higher yields in a well-drained land class may indicate that performance can be improved by better tilth, or moving a crop to a drier period, on a less well drained class. Nonetheless, a pattern may be recommendable choice on a land class that is evidently suboptimum for its performance.

In the Manaoag pattern trials, green corn yielded well on the deep water table (Table 8), but failed on the shallow water table (Table 1). Field observations of water logging confirm the conclusion indicated by differential performance on the two land classes that green corn needs to be better drained when planted on a shallow water table. Redesign to plant green corn on ridges, earlier in the season, or not at all, are possible solutions.

Disaggregating labor data by operation is more helpful to this kind of analysis than the manner in which they have been presented here. Disaggregate data from these same trials indicate that labor time for each tillage operation for rice are much higher on the shallower water table. The economic performance of rice might be improved if fewer operations are performed, say by deleting a plowing.

Within land classes on both water table levels, labor and materials costs on experimental patterns are far higher than on farmers' patterns. Material costs are 3 to 5 times higher and labor costs are anywhere from the same to twice as high as that on farmers' plots. Higher labor costs are partly accounted for by higher yields requiring more harvest labor, but the material costs may be redundant, or earning a low marginal return. Researchers should review levels of material inputs, with the objective of reducing them. Component technology trials should perhaps be conducted if the productivity of present levels is in doubt. (Fertilizer trials in Manaoag were in fact conducted in 1977-78 for this purpose and it was found that excessive levels were applied in 1976-77).

Use of post-adoption information

Farmers' adoption of experimental patterns places the trials in a different light. Acceptability would appear no longer to be a question. Redesign and testing might continue if it is felt that a greater margin of profitability might assure adoption in dissimilar environments where potential profit may be less than where the patterns were tried.

The adoption of new patterns also provides an opportunity to define more precisely the relationship between cropping pattern management and performance in trials, and management and performance when patterns are adopted by farmers. The tendency of farmers to apply fewer inputs and get lower yields than researchers has been mentioned. This phenomenon is central to the constraints studies conducted by the International Rice Agroeconomic Network.

It is not a matter of reason but of expediency that cropping systems researchers have not investigated the "why" of lower inputs and yields of new patterns under pure farmer management. Rather, the decline in performance of new patterns is regarded as an unavoidable feature of technology transfer, for which the 30% rule compensates when patterns are reviewed for possible recommendation.

The question remains, might recommendations be more sound, or might yields be further improved if study is undertaken of the factors that bring about performance declines when new cropping patterns are not supervised by researchers.

The Manaoag data indicate that net returns of the rice-mung pattern are 4.6 times greater on trials than on farmers' fields, material costs are 4.8 times higher, and labor costs are double. Higher fertilizer, insecticide, and herbicide costs all contribute to the higher costs.

I am likely incorrect to conclude that, upon adoption the performance of new patterns always changes in the manner seen above. In Iloilo, it appears that on average, farmers reduce labor by half, leaving cash inputs nearly the same, and up with 2/3 the yield of pattern trials. Without considering "why" the changes occur in performance, considerable work is needed to better predict and measure them.

As a final note at least in the case of the 1976-77 Pangasinan trials, it appears that there may be greater scope for increasing production through higher input levels in the deep water table areas. In figure 1 total returns are plotted against total costs, for all farmers' and experimental patterns. The experimental patterns in deep water table areas generally reflect a technology that provides higher levels of production, at higher levels of costs, but not much less efficiently than farmers' patterns at low input-output levels. The results imply that yet higher levels of inputs might be applied with profitable results. Higher levels of inputs with the kinds of technology being used in the shallow water table areas would not appear to be profitable.

Issues for comparable cropping systems network studies

A number of points have been made in this note, not too conclusively, about the objectives, methods and assumptions of analysis of cropping pattern trials. Comparable, network wide comparisons of the performance of cropping patterns might be undertaken for the following purposes:

1. To validate criteria used for pattern recommendation

2. To further develop and demonstrate the use of pattern trial information for redesign activities

3. To provide researchers with greater knowledge of the ranges and tendencies of key measures of pattern performance

4. To better identify the relationship between cropping pattern trial and post-adoption performance.

Table 1. Performance of existing and experimental rice cropping patterns, shallow water table areas, Manaoag, Pangasinan, Philippines, 1976-77.

Class[a]	Cropping Pattern Crop[b] 1	2	3	Observations (no.)	Crop yield (t/ha) 1	2	3	Rice Equivalent yield[c] (t/ha)
1 - F	TPR	-	-	6	1.16	-	-	1.16
2 - F	TPR	TPR	-	17	2.28	1.63	-	3.91
3 - F	TPR	Mung	-	24	1.82	0.27	-	2.90
4 - F	TPR	Tomato	-	10	2.31	3.77	-	6.08
3 - BF	TPR	Mung	-	8	2.84	0.31	-	4.08
5 - E	WSR	Sorghum	-	3	3.89	1.22	-	5.11
6 - E	GC	TPR	Mung	4	0	3.75	0.33	5.07

[a] A different numbers are assigned to different crop combinations. Also, "F" denotes farmers present patterns observed through farm record-keeping; BF denotes the best 1/3 of the "F" observations in terms of net income, and E denotes experimental patterns managed by farmers on their fields under researcher supervision.

[b] TPR - transplanted rice, WSR - wet seeded rice, GC - green corn.

[c] Based on the following price weights: rice, 1.0; green corn, 0.2; mung, 4.0; tomato, 1.0; sorghum, 1.0.

Table 2. Material inputs used in existing and experimental rice cropping patterns, shallow water table areas, Manaoag, Pangasinan, Philippines, 1976-77.

Cropping pattern class	Cash cost for material input (₱/ha), by crop														
	Seed			Fertilizer			Insecticide			Herbicide			Others[a]		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1 - F	171	-	-	68	-	-	6	-	-	-	-	-	-	-	-
2 - F	117	104	-	140	147	-	27	24	-	-	3	-	-	-	-
3 - F	114	175	-	145	-	-	16	23	-	2	-	-	-	-	-
4 - F	125	-	-	199	42	-	11	37	-	-	-	-	-	-	-
3 - BF	146	170	-	138	-	-	3.	30	-	5	-	-	-	-	-
5 - E	102	17	-	520	455	-	152	98	-	112	119	-	-	-	-
6 - E	23	66	130	556	452	339	-	229	271	-	122	188	-	21	-

[a] Soil treatments e.g. Zinc sulfate and Iron oxide.

Table 3. Labor and total variable costs of existing and experimental rice cropping patterns, shallow water table areas, Manaoag, Pangasinan, Philippines, 1976-77.

Cropping pattern class	Labor costs by crop				Materials costs by crop			
	1	2	3	All	1	2	3	All
1 - F	771	-	-	771	245	-	-	245
2 - F	1047	842	-	1889	284	278	-	562
3 - F	942	319	-	1261	277	198	-	475
4 - F	1058	1606	-	2664	335	79	-	414
3 - BF	1361	399	-	1760	320	200	-	520
5 - E	1875	459	-	2334	886	689	-	1575
6 - E	178	1971	628	2777	579	890	928	2397

Table 4. Costs and returns of existing and experimental rice cropping patterns, shallow water table areas, Manaoag, Pangasinan, Philippines, 1976-77.

Cropping pattern class	Obser-vations (no.)	Gross returns	Labor costs	Total materials costs	Net returns	Return per man hours	Return/₱ materials cost	Crops per year
1 - F	6	1518	771	245	502	2.8	6.2	1
2 - F	17	5091	1889	562	2640	5.1	9.0	2
3 - F	24	3300	1261	475	1564	4.4	6.9	2
4 - F	10	5626	2664	415	2546	2.2	13.6	2
3 - BF	8	5335	1760	520	3055	5.7	10.3	2
5 - E	3	6834	2334	1576	2924	2.0	4.3	2
6 - E	4	6631	2778	2398	1455	1.3	2.8	3

Table 5. Performance of existing and experimental rice cropping patterns, deep water table areas, Manaoag, Pangasinan, Philippines, 1976-77.

Class	Cropping Pattern Crops 1	2	3	Observations (no.)	Crop yield (t/ha) 1	2	3	Rice equivalent yield (t/ha)
1 - F	TPR	-	-	6	1.89	-	-	1.89
2 - F	TPR	Mung	-	27	1.04	0.23	-	1.96
2 - BF	TPR	Mung	-	9	1.45	0.26	-	2.49
2 - E	TPR	Mung	-	10	3.37	0.68	-	6.09
4 - E	GC	TPR	Mung	3	13.4	3.59	0.33	7.59
5 - E	TPR	Sorghum	-	4	3.31	1.82	-	5.13

Table 6. Materials inputs used in existing and experimental rice cropping pattern, deep water table areas, Manaoag, Pangasinan, Philippines, 1976-77.

Cropping pattern class	Cash Cost for Material Input (₱/ha), by crop														
	Seed			Fertilizer			Insecticide			Herbicide			Other		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1 - F	132	-	-	63	-	-	19	-	-	3	-	-	-	-	-
2 - F	114	147	-	114	-	-	9	49	-	1	-	-	-	-	-
2 - BF	120	150	-	111	-	-	11	57	-	-	-	-	-	-	-
2 - E	57	156	-	520	355	-	213	544	-	123	93	-	32	-	-
4 - E	30	55	118	733	486	473	79	139	233	-	136	268	-	31	-
5 - E	56	31	-	528	434	-	119	196	-	120	88	-	32	-	-

Table 7. Labor and total variable costs of existing and experimental rice cropping patterns, deep water table areas, Manaoag, Pangasinan, Philippines, 1976-77.

Cropping pattern class	Labor Costs by Crop				Materials Costs, By Crop			
	1	2	3	All	1	2	3	All
1 - F	1075	-	-	1075	217	-	-	217
2 - F	806	387	-	1193	238	196	-	434
2 - BF	1031	431	-	1462	242	207	-	449
2 - E	1618	863	-	2481	945	1148	-	2093
4 - E	555	1492	577	2624	842	847	1092	2781
5 - E	1704	594	-	2298	855	749	-	1604

Table 8. Costs and returns of existing and experimental rice cropping patterns, deep water table areas, Manaoag, Pangasinan, Philippines, 1976-77.

Cropping pattern class	Observation (no.)	Gross returns	Labor costs	Total materials costs	Net returns	Return per man hour	Return/₱ materials cost	Crops per year
1 - F	6	2459	1075	217	1167	3.0	17.3	1
2 - F	27	2321	1193	434	694	2.2	5.3	2
2 - BF	9	3363	1462	449	1452	2.8	7.5	2
2 - E	10	7768	2481	2093	3194	2.1	3.7	2
4 - E	3	8501	2624	2781	3099	2.0	3.1	3
5 - E	4	7017	2298	1604	3115	2.1	4.4	2

CROPPING SYSTEMS RESEARCH ACTIVITIES IN INDONESIA

Suryatna Effendi and Jerry L. McIntosh[1/]

Introduction

This paper describes the highlights of the cropping systems research in CRIA including research that has been done, is being done and needs to be done in the near future.

The research was started in 1973 in Indramayu and Lampung from funds routinely budgeted for Cropping Systems by CRIA. Supplemental funding was received from the International Development Research Center of Canada through IRRI in 1975 for initial two year period. The expaded activites that resulted from the additional funding has been of great value. We have been able to increase the number of research sites within each target area from one up to three. Funds for an annual workshop, short term training in Indonesia and at IRRI and degree training have provided the environment and the level of techanical expertise needed for good research.

The Cropping Systems research is problem oriented. Target areas are selected for in depth research. For each target area the activities include identification and quantification of problems or possibilities, evaluation of new technology in the field, pre-production testing (pre BIMAS testing) and transfer of technology to new target areas as shown in Fig. 1.

At each step the Extension Service is involved. Usually the research phase lasts for three years and the involvement of the Extension Service and other provincial Services increase each year. In this way the interface between CRIA and Extension as well as Extension and farmers is increased and the provincial planning Agency (BAPPEDA) involved BAPPEDA together with the Agricultural Extension Service plays a big role for establishing as well as supporting production programs. CRIA's targeted inputs ends with the implementation phase. But of course the routine support continues.

Research result in target areas

Significant results and implications from the research may be summarized as follows:

[1/] Cropping Systems Agronomists, Central Research Institute for Agriculture (CRIA) and CRIA/IRRI Program in Indonesia, respectively.

A. Indramayu

This area represents the irrigated and partially irrigated lowland rice producing areas of Java (including smaller areas of the outer islands). Presently, there are about 3.94 million hectares of irrigated rice land in Indonesia Generally, two crops of rice per year are planted on 50% of this land. From our research in Indramayu it has been shown that except for two years with a long wet season the yield of the second rice crop was reduced because of insufficient water in the partially irrigated areas with less than 9 months of irrigation water. This has been particularly true if the rice varieties used needed more than 120 days to mature. The data show the potential for two good rice crop yields and a legume crop in one year. For these irrigated areas totalling more than 3.94 million hectares enough rice could be produced to meet most of the Indonesian need. Preliminary research results for 1977-78 showed that IR36 followed by IR36 produced avarage yields within 240 days of 6.8 tons/ha and 5.7 tons/ha for the first and second rice crops, respectively. Furthermore there was sufficient time and water for a soybean crop after either one or two rice crops. Taking into account losses from insects and diseases and the amount of land that is presently double cropped the average yield of rice should exceed 4 tons/ha for 6.6 million hectares of crop harvest land. This would result in a total rice production of 26.4 million tons of gabah or 17.55 tons of beras. Based on a per capita consumption of 120 kg this is enough rice for 145 million people. The average yield of soybean should be at least 0.7 ton/ha for 3.94 million hectares of land to give a total of 2.76 million tons. Based on a minimum daily requirement of 55 gm per day this yield of soybean (35% protein) would provide enough protein for approximately 48.1 million people for one year and could supply 0.50 million tons of edible oil. The present cooking oil shortage could be alleviated and there would be sufficient protein to supplement the starch produced from cassava in the outer islands and Java. These kinds of data and calculations raise two very important questions. First of all, are the basic assumptions true. Secondly, if the assumptions are true, why have the present production programs not produced the same results?

The best data available for land area in irrigation indicate that there are approximately 4 million hectares of irrigated land in Indonesia. The exact breakdown of water availability by months is not available. But from our research in Indramayu and other places, we believe that the technology is available to grow two rice crops per year. Furthermore, we believe that in these irrigated and partially irrigated areas where considerable water control exists (for irrigation and drainage) a legume crop such as soybean (preferably soybean) could be grown after two crop of rice.

The second question is more difficult to answer. Until 1977 we did not have a high yielding early maturing rice variety like IR36. Pelita which is a vigorous high yielding variety with high quality takes about 140 days to mature. Consequently, many times the second crop has yielded only about one fourth of that of the first crop because of water stress during the flowering stage. This helps explain the fact that the average yield per hectare for all of Indonesian is about half the potential yield. The

rate of failure of the second crop in the non irrigated and rainfed areas is, of course, much higher. The availability of additional power to facilitate land preparation (to minimize the drudgery associated with rapid and timely land preparation only) and turn around time must be given some consideration. Presently, there appears to be no need for additional power for planting, weeding and harvesting. But, we feel additional power for land preparation is needed and will in the long run increase the need for an acceptable forms of labor (for example, harvesting by women, older men and children) for those who need it most by making it easier to grow extra crops.

There are other factors involved which are much more difficult to solve than fitting rice varieties to water availablity and providing new sources of power. In order to have a concentrated production program for the irrigated areas certain organizational arrangements must be simplified and strengthened. The irrigation water must start and terminate within a unit area in step with the land preparation, planting and harvesting operations for the crop sequence agreed upon. Agricultural extension, irrigation and local government officials must work closely together with the farmers in a specific irrigation and agro-climatic unit of a manageable size. Credit and material inputs (including seed) must be available on time. These conditions are not new and the present BIMAS program covers many of the same points. But new technology and effective leadership within a production complex must be combined with guaranteed markets in order to implement such a program.

B. Central Lampung

This area is representative of the rainfed upland areas with red-yellow podzolic soils infested with alang-alang and the partially irrigated soils of the same origin.

The productive capacity of these soils has been seriously questioned by many agricultural scientists. In fact they have been described as alang-alang (Imperata cylindrica) infested waste lands. There are constraints to production such as low inherent soil fertility, excessive drainage and low pH. But on the positive side there are several assets. The rainfall and distribution are very good for year around crop production. Rainfall exceeds 200 mm monthly for 6 months and 100 mm for 3 months. The remaining 3 months are drier but the average rainfall in only a little less than 100 mm. Since the soils are well drained, the heavy rains during the rainy season do not inhibit upland crops production. Run-off problems are minimized by the rapid infiltration of rain water. Consequently, the soils are leached and acid. But fortunately the soils do not contain excessive levels of aluminum. There is sufficient clay and organic matter to hold applied nutrients but fixation of phosphorus is not a problem. Insect problems (seedling maggots etc.) usually associated with upland crops can be eliminated with systematic insecticides. Consequently, these soils can be highly productive if managed properly. Fertilizers and insecticides are absolutely necessary but in amounts comparable to those used on rice on Java

necessary but in amounts comparable to those used on rice on Java on some of the best agricultural land in the world.

Research has been conducted for 4 years in these areas. During this time there have been years wich virtually no dry season and years in which there was practically no rain in May, June and July. In a sequence of upland rice + corn + cassava + peanut - rice bean we have had no trouble growing upland rice plus corn intercropped with cassava. The peanuts interplanted in the cassava grew well even in the driest years but sometimes were severely damaged by pod borers. There was difficulty in establishing a stand of cowpea or ricebean after the peanut.*

From these results and our field observations we feel that sustained crop production on these soils in feasible. Judicious use of fertilizers and crop sequences including legumes and rice can actually increase the fertility of these soils.

The crop arrangements and relative proportions of individual crops within a cropping pattern should depend upon available markets and the farmers preference. It is also important to note the highly profitable nature of cassava in this pattern (Tables 1-5). This was due to the low cost of production as well as to the high productivity of cassava. Rice also can be very profitable. But at present we still have problems with rice blast.

Limited power and markets are presently the major constraints to agricultural development in these areas. Animals seems to be the most logical power source for several reasons. They not only provide power for more land cultivation but also provide a means of utilizing the land in a productive but conservative manner. A forage grass-legume mixture for pasture grown in one part of the farmers field would provide a balanced animal diet, protect the soil and ultimately provide the manure needed for the land to be used for food crop production. Also animals offer an alternative to the traditional dependence upon food crops as the principle source of food and income. They represent a higher valued farm of agricultural production and hopefully promote a higher standard of living.

Future Research

Irrigated areas

Lowland rice based cropping patterns will be studied in several catagories of irrigation water availability in the area surrounding Indramayu covering 4 kabupatens. These areas are influenced by Jatiluhur

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* The yield figures are reported in the Annual Report, Cropping Systems Research, Indramayu and Lampung, 1976-77.

irrigation system which covers more than 250,000 hectares of land. These activities will be budgeted through the Sukamandi Agricultural Research Center as a part of the whole agricultural development scheme for the Jatiluhur irrigation system. Component technology for each crop commodity will back stop the cropping pattern research for this area. The research is projected to increase food production as well as farmer's income by developing suitable cropping and farming systems. The production program thus results will be a systems approach in order to obtain suitable, effective and profitable farming systems.

Rainfed areas

Lowland rice-based cropping systems, upland rice-based cropping systems as well as perennial crop based cropping systems will be studied in target areas that have been selected.

Development of rainfed agriculture has been recognized and reaffirmed as one of the major priority areas of action in the cropping systems research program.

The development of rainfed agriculture as one of the priority areas has been recognized as being needed to improve the inbalance of income growth and welfare gains between farmers on the irrigated lands and those in the majority on lands dependent on rainfall. A wide approach is needed, covering research, training, demonstration and development projects. Research for drought tolerant crops that are efficient users of fertilizers will be emphasized in this area. We believe that development of rainfed agriculture, with special emphasis on appropriate cropping systems and soil management, to be one of the priority research areas. This would represent at least 60% of the arable land in Indonesia. The scope of rainfed areas research should include not only high rainfall humid areas like Lampung but also low rainfall areas. For increasing and stabilizing agricultural production in rainfed areas, the research that is projected will cover among others, (a) analysis of hydro-meteorological and ecological factors for designing and selection of cropping systems, (b) selection and breeding of high yielding varieties suitable for rainfed areas particularly for upland rice. These activities will include seed production and distribution of identified crops and varieties, (c) sound soil and water conservation and management practices, (d) mixed farming with integration of crops and livestock, (e) fuller utilization of atmospheric nitrogen, organic manures and plant residues and (f) farm machinery research and development.

Increasing yield stability rather than record yields is the goal of the research. Small increases over large areas make a more significant contribution than high yields on a few farms. There should be a shift in emphasis from the individual crops to the environment and systems it has generated.

For the development of new technology the following should be emphasized particularly: (a) development of flexible approaches to crop production with the aim of increasing yield stability, (b) identification of critical inputs rather than adoption of an unselective "Package" approach, (c) improvement of food legumes, oil seed and vegetable crops by fitting them into farming system of the staple cereals, (d) increasing efficiency of fertilizers and complementary sources of plant nutrient, (e) breeding for varieties to suit "non-ideal" conditions, (f) improved seed technology and seed supply and simple local seed storage at the farm and village level, (g) integrated approach for land management techniques, farming systems and small farm mechanization, (h) food technology and simple food preservation to stabilize food supply, and (i) to identifiy major causes for low crop productivity in rainfed areas.

Improvement in farm equipment and power

Unfortunately, it is difficult to cultivate one hectare of land by hand labor from the family. Additional power is needed. This is true based on our observations for land preparation in lowland irrigated as well as in upland areas.

The older transmigration schemes provided each family with 2 hectares of land. From our studies and observations it appears a farmer has difficulty in using much more than one half hectare the first year after opening land. Gradually more land can be opened and used. But not more than one hectare can be cultivated. This is due to a lack of sufficient power for land cultivation. This remains a constraint.

There appear to be several alternative ways of solving this problem. Traditionally the farmers interplant coconut, palm, clove, coffee and tree fruit crops in the food crop areas. They can reduce and spread out labor and open more land. They derive some income from the perennial crops. These crops provide stability but are not highly productive if compared to food crops. Most important, they do not supply enough food for the family. But the labor requirement has been reduced and more evenly distributed so that more land can be used. This approach has been described as the perennial crop based cropping systems.

Some farmers have increased their power supply by adding animals to their farming systems. Some land must be set aside for forage production but more can be cultivated for food crops. In addition to power the animal can produce meat, milk and manure. Introduction of the cow into the farming system permits more efficient use of the farmers resources with a minimum of capital inputs. A stable and productive farming operation can result and the system will be more stable in terms of maintaining even increasing soil productivity and stabilizing food production for their own as well as some amount to sell.

Mechanization through the use of hand tractors for power is an alternative solution. In some instances the farmers may not want an animal. They may not like to work with animals nor have the time. A tractor might be more efficient, particularly, if the farmer has an off farm job for some supplemental income.

We need to study alternative sources of power in real farm situations. This could be easily done in new transmigration areas in Lampung and South Sumatra. It is proposed that a series of research trials be undertaken involving several combinations of human, animal and mechanical power to compare the resulting areas under cultivation, changes in labor productivity (per family unit) and production and net returns for individual crops and cropping patterns.
area

The major objective would be to assess the possible area of expansion through introduction of supplemental power. A second objective would be to examine the relative costs and benefits associated with use of alternative power sources.

Table 1. Calories and protein produced per hectare from year around cropping patterns with no and full fertilizer treatments. Cropping Systems Research Bandarjaya, Central Lampung, 1973-74.

Cropping pattern	No treatment			Full treatment		
	Yield (kg/ha)	Calories (K cal/ha)	Protein (kg/ha)	Yield (kg/ha)	Calories (K cal/ha)	Protein (kg/ha)
Corn +	455	1,615	42	1,350	4,792	124
Rice +	769	1,840	52	2,724	6,521	185
Cassava +	14,600	17,520	102	23,200	27,840	162
Peanut -	222	1,003	51	567	2,563	145
Rice bean	93	308	23	627	2,075	157
T o t a l		22,286	276		43,791	773
Gabah[1] equivalent kg/ha/year		9,325	4,060		18,323	11,371

[1] Gabah x .665 = milled rice

Average value of 6.8% protein used for conversion from protein to gabah.

Table 2. Calories and protein produced per hectare and costs and returns from year around cropping patterns. Cropping Systems Research Bandar Agung, Central Lampung, 1976-77.

Cropping Pattern	Yield (kg/ha)	Calories (K Cal/ha)	Protein (kg/ha)	Gross returns (Rp/ha)	Material costs (Rp/ha)	Labor costs (Rp/ha)	Net returns (Rp/ha)
Corn +	1,977	7,018	182	88,965)	54,375	75,600	77,241
Rice +	1,689	4,043	115	118,251)			
Cassava +	21,125	25,350	148	126,749	17,625	6,300[1]	102,824
Corn -	1,739	6,173	160	86,925	22,289	28,500	36,136
Cowpea	328	1,122	75	39,396	11,403	27,600	393
T o t a l		43,706	680				216,594
Gabah equivalent kg/ha/year		18,258	10,003				

[1] Labor costs for cassava would be increased by Rp 11,300/ha if 1/3 of costs for land preparation and weeding for the first 3 crops were charged to cassava.

Table 3. Calories and protein produced per hectare and costs and returns from year around cropping patterns. Cropping Systems Research Komering Putih, Central Lampung, 1976-77.

Cropping pattern	Yield (kg/ha)	Calories (K Cal/ha)	Protein (kg/ha)	Gross returns (Rp/ha)	Material costs (Rp/ha)	Labor costs (Rp/ha)	Net return (Rp/ha)
Corn +	2,080	7,384	191	93,600)	52,350	71,700[1]	41,090
Rice +	1,022	2,447	70	71,540)			
Cassava +	26,110	31,332	183	156,660	17,625	6,600	132,435
Peanut	385	1,740	98	115,410	33,057	54,000	28,353
T o t a l		42,903	542				201,878
Gabah equivalent kg/ha/year		17,951	7,973				

[1] Labor costs for cassava would be increased by Rp 10,300/ha if 1/3 of costs for land preparation and weeding for the first 3 crops were charged to cassava.

Table 4. Calories and protein produced per hectare and costs and returns from year around cropping patterns. Cropping Systems Research, Way Abung, North Lampung, 1976-77.

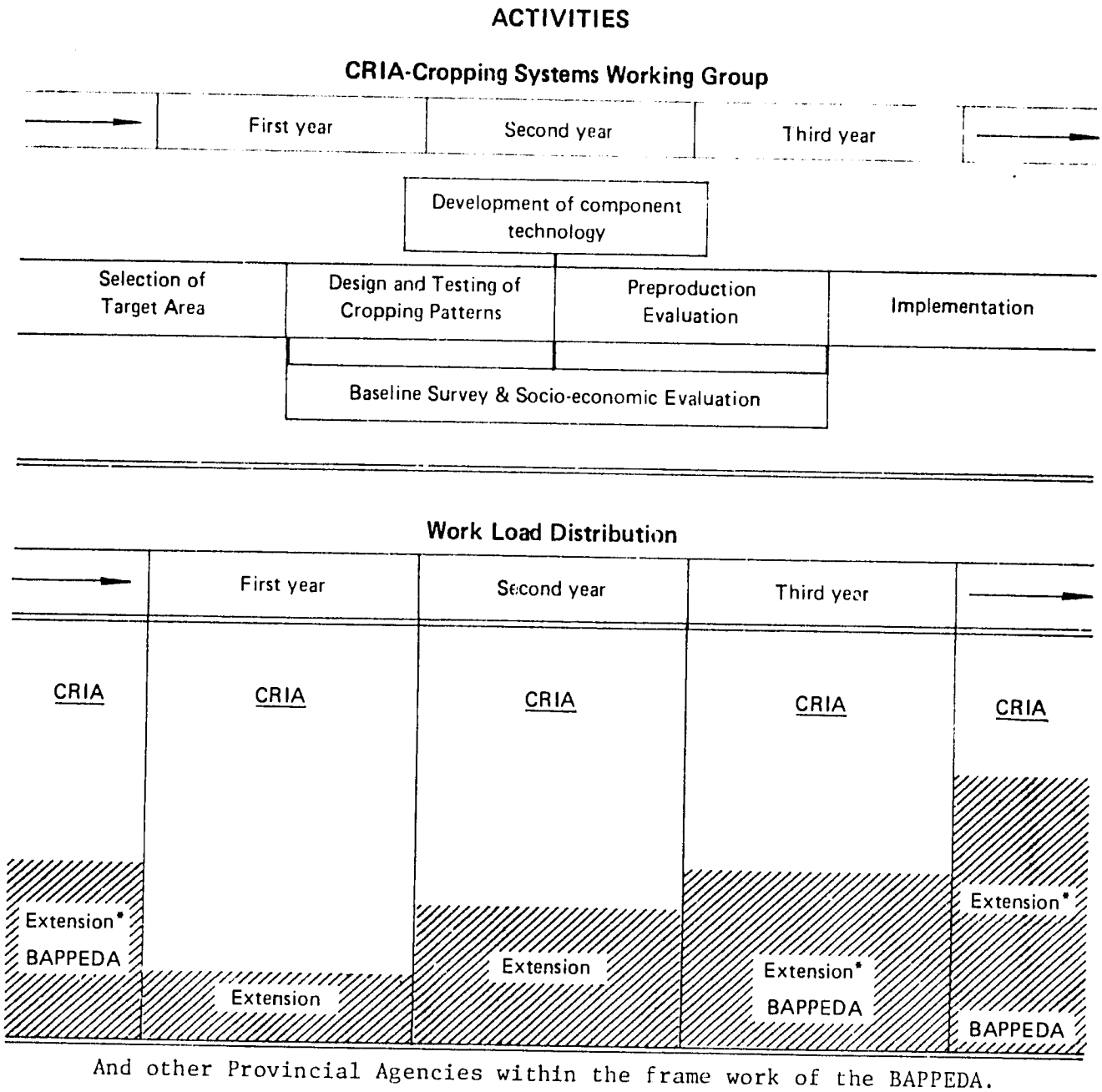
Cropping pattern	Yield (kg/ha)	Calories (K Cal/ha)	Protein (kg/ha)	Gross returns (Rp/ha)	Material costs (Rp/ha)	Labor costs (Rp/ha)	Net return (Rp/ha)
Corn +	1,169	4,150	108	46,750)	51,993	91,400	14,847
Rice +	1,858	3,448	126	111,480)			
Cassava +	22,200	26,640	155	133,200	20,722	14,700[1]	97,778
Peanut -	567	2,563	145	141,625	51,610	46,200	43,815
Rice bean	228	1,031	57	51,300	27,922	31,850	-8,472
T o t a l		37,832	591				147,968
Gabah equivalent kg/ha/year		15,829	8,694				

[1] Labor costs for cassava would be increased by Rp 13,383/ha if 1/3 of cost for land preparation and weeding for the first 3 crops were charged to cassava.

Table 5. Calories and protein produced per hectare and costs and returns from year around cropping patterns. Cropping Systems Research Baturaja, South Sumatra, 1976-77.

Cropping pattern	Yield (kg/ha)	Calories (K Cal/ha)	Protein (kg/ha)	Gross returns (Rp/ha)	Material costs (Rp/ha)	Labor costs (Rp/ha)	Net returns (Rp/ha)
Corn +	1,877	6,663	173	112,620)			
Rice +	746	1,786	51	67,140)	52,000	155,700	-27,940
Cassava +	16,649	19,979	117	166,490	20,700	36,000[1]	109,790
Peanut -	499	2,255	127	144,710	51,600	92,900	210
Rice bean	531	2,400	133	119,475	27,900	59,200	32,375
Total		33,083	601				114,435
Gabah equivalent kg/ha/year		13,842	8,841				

[1] Labor costs for cassava would be increased by Rp 21,000/ha if 1/3 of costs for land preparation and weeding for the first 3 crops were charged to cassava.



And other Provincial Agencies within the frame work of the BAPPEDA.

Fig. 1. Time phase and work load for cropping systems research in target areas.

STATUS OF RICE-BASED CROPPING SYSTEMS RESEARCH IN BANGLADESH

M. Zahidul Hoque and Peter R. Hobbs[1/]

Introduction

The rice-based cropping systems research program at the Bangladesh Rice Research Institute started in 1974. So far the major accomplishments of the program have been:

- introduction, recognition and acceptance of the systems approach in agricultural research in the country,
- general survey of the cropping systems and agro-climatic survey of the country,
- improvement of rice-based cropping systems in rainfed and irrigated areas through site-specific research. Results indicate that the present level of productivity (4-5 tons rice per hectare per year) can be doubled both under irrigated and rainfed areas through the use of judicious cropping patterns and management practices,
- constraints to higher crop yields and crop intensification have been identified in selected areas,
- suitable cultivars of several crops have been identified for use in the intensive rice-based cropping systems,
- a number of potential cropping patterns were tested at the experimental stations and few of them were identified as productive and profitable,
- methodologies have been developed, tested and refined for cropping systems research in the country,
- sixty percent of the research staff have been trained in cropping systems at IRRI and another thirty percent is now under-going training. A number of extension workers have been trained on cropping systems within the country through BRRI training programs,

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[1/] Principal Scientific Officer and Head, and IRRI Expatriate Scientist, respectively, Division of Rice Cropping Systems, Bangladesh Rice Research Institute, P.O. Box 911, Dacca, Bangladesh.

- national workshop on cropping systems research and development was organized and coordination among different research organization have been initiated,

- the program has been involved in national agricultural planning, large scale production program, applied research and agricultural development.

The future emphasis of the BRRI rice-based cropping systems program are as follows:

- BRRI research in more number of selected sites representing different agro-ecological and socio-economic conditions,

- establishment of more number of collaborative research sites throughout the country,

- intensive nationwide survey on the cropping patterns,

- undertaking of more cropping systems applied research,

- starting a regular training program on cropping systems,

- establishing strong linkages with the national production programs.

In this paper some of the research results of 1977 T. Aman, 1977-78 Boro and 1978 Aus seasons are briefly presented and discussed.

Site-Specific Research

a) Bhogra site

This is a rainfed site with Aus rice-T. Aman rice-Fallow as the major cropping pattern. Table 1 shows the percentage of different rice cropping patterns used by the farmers in three years. Farmers are trying to grow more HYV's in their patterns in this site.

The 1978 Aus crop has been harvested and the T. Aman crop is still in the field. The results on the Aus crop are given in Table 2. All the HYV's gave much higher yields as compared to that of the local pukhi variety. BR3 and BR6 varieties are comparatively profitable.

A project on whole farm study was started in 1978 Aus season at Bhogra. Six sample farms, two representing each of small, medium and large farm size groups, were selected for the study. Regular farm records were collected and maintained in prescribed forms. The 1978 Aus season data were analyzed and presented in Table 3.

In 1977-78 winter season, attempts were made to grow a third crop of water melon. The results indicate a greater potential of growing short duration water melon crop after Aus-T. Aman rice crops with supplemental hand irrigation.

b) Salna site

Salna is an irrigated rice area. The cropping intensities of this site are presented in Table 4. As it can be seen from this table, the majority of the area is double-cropped. Because of some socio-economic reasons, some lands are kept fallow and under single cropping pattern.

The extent of HYV use at Salna site is shown in Table 5. It appears from this table that the HYV's are predominantly used in this site. The results on the yields of 1977-78 Boro and 1978 Aus season crops are given in Table 6. The data of this site are now being analyzed in order to agro-economically compare the cropping patterns used by the farmers.

c) Laskarchala site

Laskarchala is an irrigated site mainly with lighter soils where vegetables and upland crops are grown before and after rice. In depressed valleys in this site continuous rice cropping is also done with irrigation.

The cropping patterns grown by the farmers at Laskarchala in 1977-78 are presented in Table 7. The percentage of HYV and local Aus rice grown at this site are given in Table 8.

Wheat was introduced at Laskarchala site by the BRRI Cropping Systems Program in 1976-77 rabi season. In 1977-78 rabi season, the farmers continued to grow wheat. The agronomic practices followed by the wheat farmers in 1977-78 are given in Table 9. The economics of two wheat varieties and barley cultivation are given in Table 10. As it can be seen from this table, it is more profitable to grow wheat than growing barley.

An attempt was made to correlate wheat yields with the level of management at this site. The data are presented in table 11. Farmers with higher yield level applied more basal nitrogen and phosphorus. Probably, the residual soil fertility and water management have also contributed to the yield differences. Intensive field experimentation and farm record keeping are in progress at this site.

d) Shimrail (DND) site

This is an irrigated site started in coordination with the Bangladesh Water Development Board at their Dacca-Narayanganj-Demra (DND)

Project area. The site has rice-rice pattern. In some cases, rice-rice-rice and rice-rice-mustard patterns are also grown. The site has been started in 1978 Aus season. Work at this site include crop cutting, pattern testing and super-imposed trials. Data collected on the Aus crop are being analyzed.

Activities at the Research Stations

a) Testing of cropping patterns

The result of the pattern testing are given in Table 12. The data for the last crop in most of the patterns are yet to be collected before analyzing the whole pattern.

Testing of cropping patterns involving jute and rice has been started in coordination with the Bangladesh Jute Research Institute. The jute crop has been harvested and the rice crop is standing in the field. Some results on the jute crop are presented in Tables 13 and 14.

b) Component technology studies

An experiment was done in the 1977-78 Boro season to see the effect of spacing and row orientation on the yield of Boro and the establisment of a relay crop of deep water rice. The spacings were 25 x 16 cm, 40 40 x 5 cm, 15 x 10 cm double row spacing with 45 cm between double rows, 15 x 5 cm double row spacing with 30 cm between double rows. There was no significant difference amongthe spacing treatments in any of the four rice varieties (Chandina, BR3, BR6, BR7). Row orientation (E-W, N-S) also did not significantly influence grain yield. The results indicated that deep water rice could be conveniently relay-cropped in Boro crop with spacings like 15 x 10 cm and 15 x 5 cm as used in this experiment.

Studies have been made to reduce the turn-arond time between the Aus and T. Aman crop by using the minimum or zero tillage techniques. Results indicate that the turn-around time could be reduced to zero between the two crops by ploughless cultivation of the T. Aman rice provided the soil is soft. In fact, relay cropping of T. Aman in Aus appeared to be promising even along with a ratoon crop from Aus. Thus a pattern of three rice crops Aus main + Aus ratoon + T. Aman plus a non-rice crop like grasspea or stubble soybean appeared to be potential for the rainfed medium land areas.

So far, it has been difficult to find a suitable mungbean variety that can be used in the program, mainly because of severe virus attack. Some of the varieties that appeared to be promising from the 1977-78 trial were as follows:

Mungbean Variety	Yield (kg/ha)
H 70-16	222
MG 174-3	178
M 350	172
CES 55	161
CES 10-21	142
M 101	106

Three soybean yield trials were conducted at Joydebpur, Barisal and Comilla. The average yields from the promising varieties were as follows:

Soybean Variety	Seed Yield (kg/ha)
Tainung No. 4	2270
Hood 75	2251
Davis	2169
Williams	2099
Bossier	1848
Hardee	1822
Semmes	1759

Other component technology studies in mixed and inter-cropping, rice + fish cultivation, stubble planting, etc. were also conducted in 1977-78.

Nationwide Projects

a) Survey of existing cropping patterns

A coordinated survey project has been undertaken in coordination with the Soil Survey Institute and the Directorate of Agricultural Extension and Management. The objectives of the survey are to update the information on the existing cropping patterns in each part of the country and to determine the effect of different factors like irrigation, fertilizer, intensive crop production and credit programs on the country's cropping pattern changes.

b) National agricultural production program

The BRRI cropping systems program is participating in a model agricultural development project in the north-western part of the country (about 35 percent of total cultivated area). Cropping pattern testing, crop cutting and field trials to determine constraints to higher yields are being conducted in about 120 deep tube well sites, one in each thana, in this area.

The BRRI Program is also assisting the government in the preparation of the agricultural production policy for the next five year plan (1980-85) period.

Future plans

The future plans of the BRRI rice-based cropping systems program include the following:

1. Continuation of work on the on-going sites.
2. Establishment of three new BRRI sites, one in deep water rice areas (Daukhandi), one in dryland farming areas (Rajshahi), one at tidal flood affected area (Barisal).
3. Establishment of 10 more collaborative sites with other organizations, 3 with BWDB, 2 with BJRI, 1 with SRI, 1 with BARI and 3 with voluntary organizations,
4. Organizing a short training course on cropping systems at BRRI.
5. Farming systems research at the station and at selected sites.
6. National workshops on cropping systems.
7. More publications.

Table 1. Varietal combination of the double rice cropping patterns at Bhogra site.

Cropping pattern		% of sample		
Aus	T. Aman	1976	1977	1978
Local	Local	24	6	6
Local	HYV	18	9	10
HYV	Local	46	56	50
HYV	HYV	12	29	34

Table 2. Average yield, management, costs and return of different Aus varieties at Bhogra, 1978.

Variety	Yield (kg/ha)	Field duration (days)	Kg $N-P_2O_5-K_2O$ per ha	Total cost (TK/ha)	Net return (TK/ha)	Benefit cost ratio
Chandina	3216	91	52-37-17	2644	4383	1.6
BR 6	3373	80	91-6-2	2169	5050	2.33
BR 3	3465	96	43-34-22	2259	5584	2.47
Pukhi	1843	-	-	-	-	-

Table 3. Labor and input use, productivity, cost and return analysis of six farms in 1978 Aus season at Bhogra.

	Farmer No. 1		Farmer No. 2		Farmer No.3		Farmer No.4		Farmer No.5		Farmer No. 6		Average or mean/ha
	/Farm	/ha	/Farm	/ha	/Farm	/ha	/Farm	/ha	/Farm	/ha	/Farm	/ha	
No. of plots	6	-	8	-	16	-	20	-	18	-	29	-	16
Cultivared land net	0.242		0.591		0.727		1.320		1.387		2.028		1.049
Area TP (ha)	0.181	-	0.168	-	0.701	-	1.077	-	0.925	-	1.729	-	0.797
% TP	75	-	28	-	96-	-	82	-	67	-	85	-	72
Area SB (ha)	0.027	-	0.034	-	0.128	-	0.229	-	.208	-	0.158	-	0.132
% SB	11	-	6	-	18	-	17	-	.15	-	8	-	12.5
Area Jute (ha)	0	-	0	-	0.026	-	0	-	0	-	0.067	-	0.016
% Jute	0	-	0	-	4	-	0	-	0	-	9	-	2.2
Total nH labor	194	1122	234	1620	662	953	1455	1103	1236	1408	1763	1049	1209
Total Tk labor	368	2081	364	2408	1009	1414	2191	1603	1749	1994	2649	1560	1843
Total Tk animal	60	338	94	465	416	501	421	321	341	301	532	282	368
Material Tk	158	1126	133	1032	491	861	796	722	725	930	735	565	873
Total cost Tk	586	3545	591	3905	1907	2776	3408	2646	2815	3225	3916	2407	3084
Gross return Tk	1892	10453	1554	9253	5994	8550	8153	7570	7382	7980	10900	6304	8352
Net return Tk	1306	6908	963	5348	4087	5774	4745	4924	4567	4755	6984	3897	5268
Yield kg	785	4337	645	3839	2487	3548	3383	3141	3063	3311	4523	2615	3465
% HYV	100	-	100	-	100	-	73	-	86	-	78	-	83
% Basal fertilizer	6	-	52	-	34	-	84	-	91	-	87	-	77
% TD fertilizer	881	-	36	-	100	-	98	-	100	-	100	-	97
% pesticide	100	-	68	-	89	-	0	-	0	-	0	-	13
% weed	67	-	64	-	92	-	82	-	96	-	93	-	89
% organic fert.	85	-	100	-	83	-	97	-	57	-	17	-	58
Return/mh labor	6.2		3.3		6.1		4.1		3.4		3.7		4.5
Return/Tk invested	1.9		1.4		2.1		1.9		1.5		1.6		1.7
Return/ah	12.2		6.9		6.9		9.2		9.5		8.3		8.3

Table 4. Cropping intensities at Salna site.

Cropping intensity	1977		1978	
	No. of plots	%	No. of plots	%
Fallow	9	11.5	11	14.1
Single cropping	5	6.4	8	10.3
Double cropping	56	71.8	55	70.5
Triple cropping	8	10.3	4	5.1

Table 5. Extent of use of HYV rice at Salna site.

Cropping intensity	Cropping pattern	% of HYV and local	
		1977	1978
Single cropping	HYV	80	100
	Local	20	-
Double cropping	Local-Local	3	0 0
	HYV-Local	11	22
	HYV-HYV	86	78
Triple cropping	Local-Local-Local	12.5	-
	Local-Local-HYV	25	-
	Local-HYV-Local	50	-
	Local-HYV-HYV	12.5	50
	HYV-Local-HYV	-	50

Table 6. Average yield of different rice varieties in Boro and Aus seasons at Salna site.

Season	Variety	No.of samples	Average grain yield (kg/ha)	S.D. yield
1977-78 Boro	IR 8	16	3813 a*	627
	BR 3	10	3582 a	790
	Pajam	13	2447 b	460
	Muktahar (Local)	2	1946 b	186
1978 Aus	Chandina	21	2519 a	456
	Pukhi (Local)	6	1705 b	172

*Numbers having different letters within a season are significantly different at 1 percent level of significance.

Table 7. Cropping patterns grown by farmers at the Laskarchala site on the highland and medium land in 1977 and 1978.

A. Pattern in Highland					1977		1978	
Rabi	-	Aus	-	Aman	No.	%	No.	%
Wheat	-	Aus rice	-	Fallow	32	60	25	45
Wheat	-	Aus rice	-	T. Aman rice	2	4	4	7
Wheat	-	Fallow	-	T. Aman	1	1.5	4	7
Wheat	-	Fallow	-	Fallow	2	4	0	0
Wheat	-	Seedbed	+ -	Mungo	0	0	5	9
Wheat	-	Aus	-	Mungo	0	0	2	4
Mustard	-	Aus	-	Fallow	0	0	3	5
Mustard	-	Fallow	-	T. Aman	0	0	2	4
Mustard	-	Aus	-	T. Aman	0	0	1	2
Vegetable	-	Aus	-	Fallow	2	4	4	7
Fallow	-	Aus	-	Fallow	11	20	2	4
Fallow	-	Fallow	-	T. Aman	0	0	1	2
Seedbed	-	Seedbed	-	Fallow	1	1.5	0	0
Fallow	-	Seedbed	-	Fallow	0	0	1	2
Fallow	-	Fallow	-	Fallow	3	5	1	2
Vegetable	-	Corn	-	Fallow	1	0	0	0
Total					55	100	55	100
B. Pattern on Medium Land								
Fallow	-	Aus rice	-	T. Aman	na	na	15	71
Fallow	-	Fallow	-	T. Aman	na	na	6	29
Total					-	-	21	100

Table 8. Percentage of HYV and Local Aus rice grown at Laskarchala site.

Season	1977		1978	
	% HYV	% Local	% HYV	% Local
A. Highland				
Aus	55	45	32	68
T. Aman	33	67	62	38
B. Medium Land				
Aus	na	na	47	53
T. Aman	na	na	43	57

Table 9. Agronomic practices of the Laskarchala wheat farmers in the 1977-78 rabi season.

	Sanalika	Tanori	Barley	Total
No. plots	32	12	2	46
% Study area	42.1	15.8	2.6	60.5
Average yield kg/ha	1754 ± 459	1774 ± 380	1204	1736 ± 455
Range yield	858-2754	1171-2515	657-1751	657-2754
No. ploughs	5.8	5.8	4.0	5.8
No. ladders	10.4	10.3	7.5	10.2
No. days land pnp	39.8	36.8	21.0	38.2
Seeding date	Nov. 17	Nov. 12	Dec. 24	Nov. 17
Seed rate	113	123	119	116
Fertilizer				
Kg $N_1P_2O_5K_2O$/ha	31-55-35*	30-62-75	16-21-0	31-57-24
% used $N_1P_2O_5 + K_2O$	100-100-25	100-83-8	100-50-0	100-94-20
Weeding	0	0	0	0
Insecticide	0	0	0	0
No. Irrigations	2	2	2	2
Harvest date	March 19	March 20	March 26	March 20
Field duration	122	129	92	122.5

* Average based only on the farmers that applied each element.

Table 10. Economics of wheat production at Laskarchala tubewell in the 1977-78 Rabi season.

	Sonalika wheat	Tanori wheat	Barley	Total
Labour				
Manhours/ha for land prep[1]	229	214	249	226
Cost Tk/ha for land prep.[1]	286	267	310	282
Animal				
Hours/ha[2]	234	215	267	230
Cost Tk/ha[2]	438	403	501	432
Inputs Tk/ha				
Seed	414	441	357	418
Fertilizer	299	291	137	290
Irrigation**	139	164	87	144
Sub-total	852	896	582	852
Harvest costs	228	305	189	246
Total costs*	1822	1898	1595	1832
Gross return ***	4386	4435	3010	4339
Net return	2564	2538	1415	2507

* Does not include cost spreading seed or fertilizer or threshing and carrying costs.

** Estimated at rate 14 Tk/ha

*** Based 100 Tk/md

1. Assumed 8 hrs/day, 10 Taka/day
2. Assumed 8 hrs/day, 15 Tk/day-pair

Table 11. Agronomic practices and economics for wheat samples taken at Laskarchala tubewell in the 1977-78 Rabi season at 3 yield levels.

	Less 1500	1500-2000	More 2000 kg/ha
No. of samples	15	15	16
Av. yield kg/ha	1259	1671	2243
Seeding date	Nov. 18	Nov. 17	Nov. 16
Seed rate kg/ha	118	109	121
Harvest date	March 20	March 20	March 19
Duration	122	123	125
Urea basal (%) kg/ha	(7) 17	(13) 16	(19) 24
Urea topdress (%) kg/ha	(100) 23	(100) 25	(100) 35
Urea total (%) kg/ha	(100) 24	(100) 27	(100) 39
TSP (%) kg/ha	(93) 47	(100) 59	(88) 63
MP (%) kg/ha	(13) 26	(20) 24	(25) 23
No. irrigation	2.0	2.0	2.0
No. plough	5.9	5.8	6.2
No. ladder	10.1	10.3	10.9
Labour cost Tk/ha	269	298	280
Animal cost Tk/ha	411	454	431
Imput cost Tk/ha	789	841	920
Total cost Tk/ha	1674	1904	1912
Gross return Tk/ha	3147	4177	5609
Net return Tk/ha	1473	2273	3697
Benefit/cost ratio	0.88	1.19	1.93

Table 12. Results from cropping patterns tested at Joydebpur, 1977-78.

	Cropping Pattern			Yield (kg/ha)		
	1st Crop (Boro/rabi)	2nd Crop (Aus Season)	3rd Crop (Aman Season)	1st Crop	2nd Crop	3rd Crop
1.	BR6	Chandina	BR3	3630	2619	In field
2.	BR3		BR4	4704	-	In field
3.	Sonalika wheat	Dular	BR4	2578	995	In field
4.	Sonalika wheat	Hashikalmai	BR4	2578	1146	In field
5.	Chickpea	Jute	-	3015	Harvested	
6.	Lentil	Jute	-	2510	Harvested	
7.	Mustard	Peanut		523	1291	
8.	Sunflower	Cowpea		2183	1534	
9.	Potato	Corn	DS rice	3262	1567	In field

Table 13. Yield of two jute varieties at two levels of fertilizer application.

Variety	Fertilizer level	Yield (kg fibre/ha)	Field duration (days)
CC 45	FF*	1105	140
	RF	1427	140
CVL-1	FF	691	123
	RF	1153	123

FF - 5 tons cowdung/ha RF - 30-10-20 kg N-P_2O_5-K_2O per ha pins 5 tons cowdung/ha

Table 14. Yield of two jute varieties at different seeding and harvesting dates (BRRI, 1978).

Variety	Seeding date	Harvest-ing (date)	Field duration (days)	Fibre	Yield (kg/ha)
CC45	16-2-78	15-6-78	119	1290	-
		29-6-78	113	1378	-
		13-7-78	147	1631	-
	27-2-78	26-6-78	119	1428	-
		10-7-78	133	1275	-
		24-7-78	147	701	-
	15-3-78	12-7-78	119	1391	-
		26-7-78	133	1096	-
		9-8-78	147	1155	-
CVL-1	16-3-78	28-6-78	104	-	1329
		12-7-78	118	-	1140
		26-7-78	132	-	1229
	5-4-78	19-7-78	105	-	465
		2-8-78	119	-	401
		16-8-78	133	-	451
	26-4-78	2-8-78	98	-	385
		16-8-78	112	-	440
		30-8-78	126	-	440

CROPPING SYSTEMS WORK IN THAILAND

Damkheong Chandrapanya[1/]

Rice-based cropping systems research in farmers' fields has been conducted systematically in 1977 at four locations namely Pimai and Ubon in the Northeastern Region, and Bangpae and Inburi in the Central Region of Thailand. The first three sites are in the rainfed lowland category and the fourth site represents the partially irrigated condition. The program is assisted technically and financially by the International Development Research Centre. Organizational Chart on page 62 showed the set-up of agencies involving in the conduction of the research experiments. Ubon and Pimai sites are under the agronomic supervision of the Rice Division while Inburi is under the Technical Division, both of the Department of Agriculture. Economic research supervision of these three sites is under the Division of Agricultural Economics of the Ministry of Agriculture and Cooperatives. Faculty of Agriculture in cooperation with Faculty of Economics and Business Administration of Kasetsart University is responsible for the agronomic and economic research efforts of the last Bangpae site.

In connection with the research attempts, there are six rice experiment stations in the Northeastern Region, three in the Central Region, helping in the back-stopping researches within the stations. Regional Research Centers in the Northeast and in the Central Regions are also doing cropping pattern trials within the centers producing useful information for the rice-based cropping systems work in farmers' fields.

The program is a coordinated one among researchers and instructor-researchers of the agencies involved. So that good cooperation among people concerned is the first priority for the success of the research undertakings. Even though resaarch responsibilities are divided into four major locations, regular interchange of ideas, and physical and technical helps among different workers are always presented as the work is progressing on. This report is trying to present the cooperative linkage, research activities, agronomic and economic results and analyses. Four major research locations will be described lengthly with the addition of other research activities presently going on in the country. The report will also present the training component of the program together with future plans.

[1/] Head, Rice Culture Improvement and Seed Storage Branch, Rice Division, Department of Agriculture, Bangkhen, Bangkok-9, Thailand.

A. Ubon site

A.I. Description of the site

Ubon site is located in the Northeastern Region. It is in the eastern part of the Northeast representing a rainfed area of about 500,000 hectare. By road, it is about 700 kilometer from Bangkok. There are three seasons in the area: the monsoon rainy season from May to September, the cool season from November to February and the warm season during March and April. Ubon area receives rainfalls regularly during the early monsoon but rains cut off sharply toward the end of the rainy season (Fig. A.1). Rainfall distribution is unimodal. In 1977, drought situation occurred in the area during the early part of the monsoon rainy season. Rains started in the latter part of April recorded at 62.5 mm. for the month. Rainfall was normal in May but the amount of it dropped to 81.7 mm. for the month of June creating unsufficient rains for farmers in the area for the preparation of rice seedbed. Again in July, rainfall amount was one-half below the average. However, rains in August and September were plenty and farmers transplanted their rice crop even though the length of time for the crop growth from transplanting to harvest was short for the local photoperiod sensitive varieties. Then the rains stopped abruptly in October recorded at 38.8 mm. which was one-half of the average representing the occasional sudden end of rainfall pattern for the area. The situation was not condusive for good yield of rice due to the inadequate amount of rains for the rice panicle formation. Soil series in experimental sites mostly belong to Roi-Et and Ubon series. These soils are sandy loam to loamy sand to sandy. Soils are low in fertility with percent of organic matter content about one percent or less, pH values range from 4.5-5.5 for the Roi-Et series and 5-5.5 for the better drained Ubon series. C.E.C. value is 1.2 me/100 gm on the average. Farmers usually grow one crop of rice and getting rain yield about 1.5 ton per hectare on the average from size of five hectare. In connection with the abrupt cessation of precipitation at the end of monsoon in some years, rice could not have enough moisture for the grain formation which is resulted in low yield.

A.II Designed cropping patterns

The testing cropping patterns are to utilize the soil moisture effectively. Figure A.1 shows the rainfall distribution of the tested site. Early photoperiod sensitive varieties of rice are required. Rice will either be direct-seeded or transplanted during middle of June through the end of July. Rice will then be harvested in early November. An upland crop will be planted either relaying or in sequential after rice. Or two crops of rice can be grown during the monsoon by using non-photoperiod direct-seeded as first crop and then is followed by the photoperiod transplanted rice. In 1977, a pattern is being tested using vegetables as first crop and followed by transplanted rice as a second crop. Because of the terrace-like topography of land in the site, the last pattern can be done by planting vegetable in upper fields which have better drainage.

A.III Methodology and Results

In 1977 cropping patterns trials have been conducted in 15 farmers' fields at the Ubon site. Figure A.2 showed the patterns and their planting and harvesting time during the year. Results of the trials are presented in Table A.1 and are discussed as follows:

Pattern No. 1 Yard long bean + rice. By growing the yard long bean in early May, the crop could be harvested in the middle of Agusut. Results from the test showed that the pattern could be practiced successfully except for one plot which has been damaged by sudden flood. One factor which merits consideration is the market situation of the vegetable. This is a high risk crop and a great amount of yard long bean available at the market may reduce the price of it. However, at the time of harvesting or the crop in August, the scarcity of the product at the market in Ubon commanded a reasonable price indicating good chance of the crop to be accepted by the farmers. Yield of rice which followed the yard long bean is considered low (1.4 ton/ha) in terms of fertilizer applied (50-31-25 kg/ha of N, P_2O_5 and K_2O respectively). The reason was time between transplanting and flowering of the variety NSPT was short (70 days) and insufficient for a good plant growth. Adjustment of rice variety by using a non-photoperiod sensitive one may be the answer for the better rice yield.

Pattern No.2 Rice-cowpea. Rice variety used was RD 6 a recommended glutinous photoperiod sensitive one. Direct seeding method was better than transplanting in terms of producing better yield for the crop giving 2.7 ton/ha as 1.2 ton/ha respectively. There is a possibility of growing cowpea successfully after rice utilizing limited residual moisture but market introduction of the crop is required. People in the area are not familiar with the crop.

Pattern No.3 Rice-glutinous corn. One problem associated with harvesting rice in the middle of the growing season when no other rice is in the surrounding fields is the rat and bird damages. One plot assigned to the pattern was lost due to this problem but the other two plots produced reasonable yields of 2.5 ton/ha by using non-photoperiod sensitive variety RD 9 and direct planting. Glutinous corn after rice promises to bring more income to the farmers. Quite a number of marketable ears (23,500 ears/ha) of corn were harvested from the pattern trial but the problem of not enough moisture for corn has to be considered.

Pattern No. 4 Rice-peanut. This pattern is considered as having great potential for the research site. RD 7 produced reasonable yield of 2.7 ton/ha by direct planting. Peanut has some tolerance to drought or limited moisture after rice planting. The peanut yield averaging 1.1 ton/ha is considered low but with minimum labor and fertilizer inputs a crop of peanut could be obtained producing more income. Rice-peanut combination indicates a stable pattern, more refinement on agrotechniques and crop variety used could produce a very acceptable pattern.

Pattern No. 5 Rice-rice. This pattern at the design stage shows promise. But the first rice PMI6646-3-4-15, a glutinous non-photoperiod sensitive selection is susceptible to root-knot nematodes especially under the non-submerged soil condition. Two plots have been destroyed by the root-knot nematodes. The following crop of rice did not perform well due to the relatively short period of time for the growth duration of the HY 71 variety which is a glutinous photoperiod sensitive variety normally harvesting about November 4. New varieties that will meet these conditions are needed.

For the Ubon cropping pattern trials as a whole direct seeding of rice is the focal point that other upland crops or rice should be evolved around this method of rice planting. Some of the results are encouraging and meriting further study; rice-peanut pattern indicated stable combination and rice-cowpea suggesting a possibility except market outlet of the crop is a problem. Instead of one rice crop in a year under rainfed condition, research findings point to another upland crops or rice which will bring more income to the farmers.

A.IV A short description of cropping systems experiments in 1978

After the 1977 results and experiences, six cropping patterns are selected for testing in 24 farmers' fields in four villages at the Ubon site in 1978. Within a selected village a complete set of six patterns is included. There are 2 double cropping and 4 sequential cropping patterns. It is almost certain to the research team that three-crop-patterns can be grown successfully under the rainfed condition such as Ubon. Farmers are very cooperative this year after they have seen what crop could be possibly grown in their area in 1977. Crops such as peanut, mungbean and yard long bean will gain the prominent places in the cropping patterns for the rainfed small farmers of the Ubon and similar agro-climatic locations in the Northeast Region in the future. The six cropping patterns are as follows:

1. Rice - Rice (RD 7 - RD 6)
2. Rice (RD 5) - Ratoon
3. DMR sweet corn - Rice (RD 7) - Peanut
4. Yard long bean - Rice (RD 6) - Peanut (Tainan 9)
5. Mungbean - Rice (RD 7) - Glutinous Corn
6. Peanut - Rice (RD 6) - Mungbean

In pattern No. 2, 3 and 6 fertilizer trials are super-imposed. It has been known that the Northeast soils are so poor of plant nutrients, soil improving organisms or material are always needed especially the cheap ones. Therefore, agronomic practices such as green-manure incorporation and Rhizobium innoculation are being conducted within the selected patterns. Also rice ratooning technique is tried after experience has

been gain about the ratoon work in irrigated areas. In addition, economics research and analyses are conducted accordingly.

B. Pimai site

B.I Description of the site

Pimai site is located lower western part of the Northeastern Region. It is about 300 kilometer from Bangkok. The site potentially represents the rainfed area of about 850,000 hectare for increasing cropping intensity. Climatic conditions of the Pimai site are somewhat similar to the Ubon site. There are three seasons in the area. Major difference is rainfall distribution. It is bimodal with occasional drought periods during the early monsoon. Soil types in the area are derived from semi-recent and old alluvium, textures of the soils range from light to heavy clay composed of low Humic Gley, Gray Podzolic and Alluvial soils. During the rainy season, farmers grow a crop of rice in the lowland paddy fields, cassava, kenaf and others in the upland fields. Average farm size is about five hectare. Due to erratic rainfall during early monsoon season, rice cultivation is risky especially transplanted rice. Farmers are poor and in some years they have to abandon their farms and seek work in the urban area. This is mainly attributed to the normal occurring of drought periods during the early monsoon. So that stabilization of rice cultivation is needed and in addition, introduction of field crops in the lowland paddy area to be grown during the early part of the monsoon is also required. The practices will increase the cropping intensity and income.

In 1977, rainfall record examplified the typical bimodal distribution of the area, (Fig. B.1). Southwest monsoon rains started in April and gradually increasing to the first peak of the bimodal in May recorded at 200 mm. for that month. The rains then dropped to 122 mm. in June reaching the bottom between the two peaks in July for a 63 mm. rainfall record. Toward the end of July and the beginning of August, there was a period of 2-week rainless days. The rains started to build up their second peak on the sixth of August and the monthly record was 265 mm. Again in September the amount of rain was above the 200 mm. mark. Rainfall record was then went down to 76 mm. for October signifying the end of Southwest monsoon rain for the Pimai area. This year, farmers could not grow transplanted rice until August indicating severe water shortage in the fields at the early monsoon season. It was worth mentioning that the year marked one of the worse droughts situation for the Northeastern region in years causing 30 percent damages to the rice crop of the region.

B.II Designed cropping patterns

The rainfall pattern typical of Pimai area is bimodal, rain usually comes in April sufficiently enough for land preparation and crop growth. The testing cropping patterns are developed to utilize the first

rains of the monsoon. Crops to be grown during the time should utilize moisture effectively. Fourteen-year rainfall average records at the Pimai Rice Experiment Station indicated that there were about 30 and 75 mm during March and April and approximately 150 mm each during the months of May through August (Fig. B.1). In designing the cropping patterns, the requirement is to have field crops with short maturity and possessing some degrees of drought tolerance to be grown before rice. The crops will be grown starting from the middle of April and to be harvested in July. Crops under consideration are mungbean, peanut, glutinous corn and vegetables. After harvest the upland crops, rice could be grown either direct-seeded or transplanted After the rice has been harvested in November, third crops in the cropping sequence could be tried to utilize the residual moisture in the fields.

B.III Methodology and Results

The cropping patterns to be tested are:

First crop: mungbean, peanut, corn, cucumber, corn/mungbean

Second crop: 3 rice varieties; KPM 148, HD and KDML 105

Third crop: Pumpkin

The farmers were selected around four different sites so there are four groups of farmers. In each group there were five farmers.

Twenty farmers have cooperated with the research team to conduct the experiments in 1977. The first-second crop combinations namely mungbean-rice, peanut-rice, cucumber-rice, corn-rice and corn-mungbean intercrop-rice could be grown with some successes for soil salinity and drought except some plots which are damaged by soil salinity spots. The third crop pumpkin due to limited residual moisture in the soil.

The results of the trial together with the fertilizer component technology are presented as follows:

Cropping pattern and super-imposed fertilizer trials at Pimai site

Pattern No. 1 Mungbean-Rice. Previous experiment in 1976 showed that mungbean grown before rice could be practiced in the Pimai area producing an average yield 500 kg/ha from three farmers' fields, the pattern was tested again in 1977 utilizing 7 rates of fertilizer applications for the determination of fertilizer response on mungbean. The results are shown in Table B.1. Even though some of the tested plots were located in the salinity spots and no yield was obtained, two farmers produced reliable yield for analyses with means of 0.5 ton/ha mungbean and 2.3 ton/ha rice. It was concluded that for the upland crop. The variability in the field and the lack of response of mungbean to the lower levels of fertilizer suggest that little or no fertilizer will be used by farmers. The phosphorous had some effect but more work will be

needed to optimum levels. The negative effects of potash would indicate no more should be used.

Pattern No. 2 Peanut-Rice. The high degree of variability between farms made testing of patterns very difficult and analysis of components in the pattern nearly impossible. Two factors stood out in this pattern. Added potash had a strong negative effect on yield. This response was also observed in mungbean but not as strongly. Phosphorous appears to have become a limiting factor at the higher rates of nitrogen and may be the main nutrient constraint (Table B.2).

Pattern No.3 Glutinous Corn-Rice. Drought conditions during the growth of corn resulted in low yields which did not even show corn being responsive to nitrogen. It is of interest that those plots which did not receive phosphorous had the lowest yields (Table B.3).

Pattern No.4 Cucumber-Rice. The yield of cucumber in the plot with the highest level of fertility was in the high end of the field and so suffered more stress than the other plots. Considering the first 6 treatments it appears all major elements are needed with nitrogen and phosphorous being the most important for cucumber (Table B.4).

Pattern No. 5 Glutinous Corn/mungbean intercrop-Rice. The corn yield levels off at 125 kg/ha of NPK indicating that other factors became limiting. The mungbean shows no response to fertilizer nor did it seem particularly affected by the stand of corn (Table B.5).

In the five patterns under investigation, the rice yields tend to show some increase in yields due to a residue effect of fertilizer from the first crop, the increase is not significant. This slight increase in yield occured in several of the patterns. Further research is needed on residue effects.

To gain a better understanding of the variability of yields a comparison between the soil analysis and yields of each field was made. It was found that there was a highly significant relationship between the percent silt and total nitrogen available in the soil and yield of peanuts. Calcium and percent clay were found to have significant relationship with yield of peanuts. There was no relationship found between yields of corn, mungbean and corn/mungbean intercrop and the components of the soil. Further soil samples were taken to gain a better understanding of the effect of salinity on various crops but analysis is not completed at this time.

Economics of Fertilizer Trial at Pimai Site

There are several conclusions that can be drawn from the economic study of the fertilizer trials at Pimai (Table B.6). First fertilizing legume crops does not appear to pay. The legumes do not increase yield enough to pay for the fertilizer and at low rates there is very little residual effect on the following rice crop. Although phosphorous shows some effect on mungbean it is doubtful that the response is sufficient

to pay for the fertilizer. Second corn alone did not appear to be able to make as efficient use of the fertilizer as the intercrop of corn and mungbean. Even at the highest rates used the intercrop showed a positive return on money invested in fertilizer although not statistically significantly different due to a high CV. The plots that had been fertilized for corn or corn and mungbean had a 20 percent higher yield than those receiving no fertilizer on the first crop. The data on cucumbers shows a high degree of variability but no rate of fertilizer paid.

Since many of the first crops in the pattern did very poorly due to the lack of rain it is possible that in a good year some of the residue effects observed this season would not be found. It is possible a good crop would use up most of the fertilizer.

Cropping systems supporting study from Pimai Rice Experiment Station in 1977

The experiment was originally designed and conducted for five rice experiment stations in the Northeast in 1977 under rainfed lowland conditions. But results of only one experiment station was reliably obtained. Four upland crops namely, mungbean, peanut, cucumber and glutinous corn were planted before rice. Four different varieties of rice were used in connection with particular upland crops. Randomized Complete Block design with three replications was employed. Results of the experiment were shown in Table B.7. Unfortunately, results of only one location at Pimai station produced reliable data. Other stations have experienced severe drought situations and the first upland crops failed. At Pimai, average yield of mungbean was 405 kg/ha which was at the same yield level of the previous year under farmers' fields condition. Peanut yield was quite low due to poor germination. Cucumber and glutinous corn performed reasonably good. From the rice yield standpoint, RD-15 produced the highest yield followed by RD7, RD6 and KDML 105 respectively. Even though all rice entries are photoperiod-sensitive except one (RD7) the sub-normal length of growth duration of each entry did not affect the yield very much. Research results of the four patterns under study suggest that the possibility of growing selected short-maturity upland crops before rice can be done under rainfed lowland paddy field condition of the Pimai-type agro-climatic area of the Northeast.

B.IV. A short description of cropping systems research in 1978

At Pimai location, the soils are heavier than the Ubon site. Topography of the land is almost flat with sparsely grown big tree in it. The area is ideal for big tractor operation especially in the preparation of soil for early planting. So now a numberof farmers prefer to use custom plowing for their broadcasted rice growing. For the cropping systems study, 20 farmers are selected in 1978 to work with the program at Pimai. There are four cropping patterns tested:

1. Peanut (local) - Rice (KDML 105) - Pumpkin
2. Mungbean (Uthong 1) - Rice (KDML 105) - Pumpkin

3. Sesame (black type) - Rice (KDML 105)

4. Glutinous corn + peanut (intercropping) - Rice (KDML 105)

Simple fertilizer trials are super-imposed on patterns No. 1, 2 and 3. Component technology research such as variety trials of mungbean, peanut and sweet corn are conducted in a farmers' field. Entomology research is super-imposed on pattern No. 4 to test different doses of four insecticides on corn and peanut. From the 1977 encounter, it was found that leaf rollers were presented in two peanut fields causing some damages.

C. Inburi site

C.I. Description of the site

Inburi Sub-district, Inburi District, Singburi Province is the lowland plain of the Central Region, about 160 km from Bangkok with Chao Praya River running through this district. Parallel to the Chao Praya River, are the two main irrigation canals namely Baromdhart Canal and Maharaj Canal carrying water from Chao Praya Dam, Chainat Province. So that the Inburi research site receive water from both natural rainfall and irrigation water.

Soil types vary from light clay to sandy clay loam with the pH ranging from 5.3 to 5.7.

The site generally represents climatic conditions of the Central Region. Monsoon rainy season begins in May and ends in October with average rainfall approximately 1,084 mm. per year. Maximum rainfall is in September averaging 268 mm. (10-year record).

Upon consideration of the area's general condition, it is found that Inburi-Sub-district is rich in farming resources sufficient for crop growing all the year round. Dry season cropping has already been done by some farmers. By means of selecting suitable cropping patterns and improving production technology, it is, therefore, decided to choose the village No.5 of Inburi Sub-district as the research site for the experiments. This village is connected with Baromdhart Canal on the right bank of the Chao Praya River, which is on higher elevation suitable for paddy farming and growing other crops during the dry season. The land surface is gradually sloping away from the canal towards the lower plains with high water level suitable for deep-water rice using broadcasting method during the wet season. On the other hand, the tested site is closed to the roadside which is in access to communication and transporation of products to the market. Besides, this experimental site is not far from the village offering conveniences for closely research supervision.

The primary study is aiming at:

1. The study of existing resources and utilization of traditional cropping system.

2. The study of cost and retun on the tested systems.

3. Accumulation of data for future farm planning.

C.II Methodology and Results

1. The tested cropping pattern was: RD5 rice variety (transplanting) - groundnut - sweet corn.

2. There were 11 farmer-cooperators in the experiment work.

3. Each farmer will be provided with necessary agricultural materials, such as, fertilizers, chemicals, and certain amount of seed; but each has to responsible for his own labor.

4. Crops cultivation

4.1 RD5 rice variety cultivation. Transplanting RD5 rice variety at the beginning of August until the middle of August, 1976 with seedlings aging about 25-30 days. Transplanting was made according to previous practice by local farmers who usually plant 30-40 hills per sq.m. Seven to ten days after transplanting, ammonimum phosphate (16-20-0) at the rate of 20 kg per rai was first applied. Second application was done at panicle initiation stage by using ammonium sulphate (20%) at the rate of 14 kg per rai. Before second fertilizer application, weed control was done once. Regarding to insect control, Sevin was sprayed as needed. Rice was harvested starting from the latter part of November until the early part of December of 1976.

4.2 Groundnut cultivation. After rice harvesting has been completed, farmers immediately prepare the land by using buffaloes ploughing once and harrowing twice. Before the last harrowing, N-P_2O_5-K_2O fertilizers were applied at the rate of 4.8-6-6 kg per rai respectively as basal application. When the soil was turned over to cover the fertilizer then furrows were being made for row seeding with spacing of 30 cm between rows. On account of the farmer's practice, the planted groundnut without using supplementary water which help to reduce the amount of weeds causing no problem concerning with weed control. Harvesting time was made at the end of March, 1977. Harvesting groundnut is utilized as boiling groundnut by the people.

4.3 Sweet corn cultivation. Super sweet corn variety was planted at the beginning of April until the middle of April, 1977 after preparation of the fields. Seeding was done in rows with spacing between rows of 75 cm. and between hills of 50 cm. One hill consisted of 2 plants. Fertilizers were applied at the rate of 12-12-6 kg per rai of N, P_2O_5 and K_2O respectively. Ammonium phosphate (16-20-0) at the rate of 30 kg per rai together with Ammonium sulphate (20% N) at the rate of 6 kg per rai and Potassium Chloride (60% K_2O) at the rate of 10 kg per rai were applied at basal. Two hand weedings were done. When corn was about 15 days and 30 days old after the second weeding, fertilizers was applied for the second time as top dressing at the same rate as basal application. Then the soil was hilled up at base of corn plants. Corn was supplied with water from nearby irrigation canal every 7-10 days by water pumps. Azodrin was sprayed when necessary.

5. Economics study. The study was conducted in the forms of farm survey by questionaires and interviews with local farmers of Inburi. Farmers were selected at random by using the two stage probability sampling method which was described as follows:

5.1 First-Stage Sampling was made in order to randomly select about 30 percentof the whole villages in the Inburi Sub-district.

5.2 Second-Stage Sampling is to randomly select every 10 households from the villages where there are less than 100 households and every 15 households in the villages within which the numbers are more than 100 households.

At each stage, systematic sampling was employed with the exception of village No.5 which is the cropping systems research site where all 14 farmer-cooperators were put under economic study of crop growing. In addition, another 10 households in the village No.5 were selected for study representing the local farmer situation.

With the application of sampling method, information has been obtained in the survey of 3 villages with 30 families being interviewed. So that it made a total of 4 villages being surveyed and 54 families interviewed including village No. 5.

Result of study

1. Existing farming resources and their utilization.

Average farm holding or size is 32.89 rai per family. From this figure only 29.8 percent of the farm families own their land, and 9.82 percent work on the fields which were rent free of charge. The size of family is about 6 people, working persons (age 15-60 years) accounted for 59 percent.

Farmers in the studied project area on the average own 31.42 rai of paddy fields or 95.53 percent of their farm holdings. Only parts of their lands are possible for additional crop growing after harvesting the rice crops.

As regards to their capital, it could be estimated from a simple way of their saving or cash saving at 2,028.82 baht per family on the average. Labor availability for regular or permanent farm work was estimated at 2.59 man per annum plus 1 temporary farm worker (Table C-1).

In terms of land use, it was found that 9.12 percent of the farmers grew second crops after rice accounting only for 109.12 multiple cropping index. Out of their capital, they spent 8,423.70 baht for crop growing (Table C-2). Taking expenses of fertilizer and pesticide into consideration, they averaged about 3.27 and 2.23 percent of fertilizers and pesticides respectively but of the total farm expenditures. While major expenses were for land rent and hired labor accounting for 38.36 and 28.28 percent respectively. During a year, farmers spent 2412.85 hours for farming, 53.91 percent from within the family labor and 33.04 and 13.05 percent from the hired and exchanged labors respectively. It was thus indicated that the labor shortage did existed presently at Inburi.

2. The study on cost and returns of the tested cropping patterns to compare with the similar cropping patterns before the introduction of the Project.

As assumption has been made that farmer's practices of crop growing before the project had low production inputs and low management level. If given increasing production inputs especially fertilizers, pesticides, labor and management and under the supervision of the researchers, yield and returns must increase undoubtedly which will likewise increase the returns per unit area of land use. However, price of inputs and yield must remain the same as the previous years before the start of the Project.

Yield of the crops grown during crop year 1976/77 is shown in Table C-3. Table C-4 showed the cost and returns of the tested pattern. Also Table C-5 showed that net income above total variable inputs or cost (estimate plus actual expenses) of land use in a rai in a year (receive irrigation water) under the supervision and advice of the cropping systems project researchers is 3,024.99 baht. The amount is 934.45 baht more than

amount the farmers received after growing the same crop pattern which produced 2,090.54 baht per rai. It is worth noted that the increase of production factors especially fertilizers and pesticides in transplanted rice and corn contributed to the increase of crop yield as well as the increase of net income over variable costs. In the case of additional production factors to groundnut cultivation, the yield is increased unsubstantially and more capital had to be spent causing the reduction of income over variable costs. It is, therefore, firstly assumed that by increasing production inputs especially fertilizers and pesticides did not increase the groundnuts yield in a proper margin leading to the continuation of research study to find out the suitable production resources needed.

One finding which lead to an assumption was that the methods of fertilizer application may not be correct. For example, fertilizers applied by broadcasting into the last land preparation prior to planting may not appropriate. At that time, the fields had little moisture and no additional water was supplied causing the plants to utilize moisture ineffectively. Therefore, methods and levels of fertilizer application must be further studied.

C.III. Conclusion

Only one cropping pattern of RD5 rice variety - groundnuts - sweet corn has been studied at Inburi for the crop year 1976/77. Therefore, no comparison with other cropping pattern is made, except, the improvement of production inputs and management to compare with the similar cropping pattern without improvement (before the introduction of the Project). The results of the research attempts may be summarized as follows:

1. Farmers own 31.42 rai on the average of paddy land. Total crop land accounts for 32.01 rai. Farmers use only 9.12 percent of their land for the second crops after rice.

2. Farmers spent 38.36 percent of the total agricultural expenditures mainly on land tenancy, 28.28 percent on labor, 3.27 percent and 2.23 percent on fertilizers and pesticides respectively.

3. Each farm had to employ 2412.85 hours of farm labor per year, 33.04 percent of which is for hired labor, 13.05 percent for exchange labor, and only 53.91 percent came from family labor.

4. Cost of the tested cropping pattern is increased in accordance with the increase of production inputs especially fertilizers and pesticides. However, it was found that net income over variable cost of improved crop pattern was greater than the farmer-practiced pattern about 934.45 baht per rai per year (farmer pattern produced income of 2090.54 baht per rai per year, while the improved one produced 3,024.99 baht per rai per year).

C.IV. Problems and recommendation

1. Utilization of land after rice harvest appeared to be very low, the fields should be utilized for more crop cultivation purpose by means of improving irrigation systems, and levelling of land area so that the farmers get more water and use it more effectively. At present, although the cultivation area is near the irrigation canals, getting water into the fields is sometimes resorted to the use of motor-pump, causing more expenditures.

2. Since farmers lack capital and labor, plan should be laid out to use labor efficiently in connection with the cropping patterns used. Consideration must be given of finding credit for the farmers for the purchase of labor-saving equipments. Lending institutions should give special attention to this matter.

3. Market demand should also be studied as the outlet of the introduced crops in the systems.

4. Study should be conducted on the application of proper production inputs in order to obtain the highest beneficial returns especially from fertilizers and their application.

5. Different cropping patterns should be studied at the same time at the tested site in order to evaluate their performances more broadly and constructively.

C.V. Summary of Socio-economic Survey at Inburi Site

The socio-economic survey of farmers at Inburi under cropping systems project was undertaken during April 1976. The results of the survey are summarized as follows:

1. The average size of household is about 6 persons per family; male and female are about even. About 15 percent of them have finished 7th grade elementary school and 21 percent cannot read and write. The rest is in between the two groups.

2. The total average size of land holding is about 33 rai; 30 percent of them are rented. Of total land holding 96 percent are paddy land and less than 1 percent is upland area. The rest are home plot, fruit trees and vegetables.

3. Of total family members about 44 percent are permanent farm labor; 17 percent are temporary labor and the rest 39 percent are non-farm labor. The average human labor for total crop production is about 2,400 hrs. Of total human labor about 54, 13 and 33 percent are family labor, exchanged labor and hired labor respectively.

4. The survey area represents partially irrigated rice area. Rice growing is in wet saason (June-December) and the second crops after rice in dry season (January-June) are corn and legumes. The average yields per rai of transplanted rice, broadcasted rice, corn, mungbean and peanut (unshelled) are 440 kg, 350 kg, 2,400 ears, 92 kg. and 338 kg respectively. Multiple cropping index is about 109.

5. The average farm asset is about 156,000 baht and the average debt per farm family is about 2,500 baht. Of the total sample farmers about 30 percent are in-debted.

6. The total average net cash farm income is about 9,742 baht. Of total net cash farm income about 79 percent come from rice, 11 percent from second crops and vegetables and the rest 10 percent from livestock. The average family net cash income and net farm income are about 16,197 baht and 20,215 baht respectively. The average cash living expenditure of the total sample farmers is about 14,168 baht.

7. The major problems of the farmers are production, land, and indebtedness. Of the total sample farmers about 56 percent have to rent the land and 30 percent are indebted. The other problems are instability of crop prices, lack of labor and lack of proven production techniques.

D. Bangpae Site

D.1 Description of Site

Bangpae was selected to represent an agro-climatic zone in which cropping system will be studied under rainfed condition. Bangpae is one of the districts in Rachaburi province located approximately 100 kilometers south west of Bangkok. Geographically, it is located between 13° 14' and 13° 45' north latitude and 99° 51' and 100° east longtitude. The area is generally plain and approximately 2.2 meter above sea level.

There are 15,200 hectare of arable land, population is 8212 or 1440 families with the average farm size of 6 hectares. According to the baseline survey, 80% of the crop grown during the rainy season is rice. Generally, 85 percent of rice growing area are planted to broadcast method while the rest are transplanted rice. During the period before and after rice crop, mungbean is grown in the field for subsidiary income.

D.1.1 Rainfall

Twenty year average rainfall (1958-1977) ranged between 463 to 1515 mm. Generally rainfall at Bangpae is considerably low for crop requirement. However, certain areas receive supplementary water from irrigation canals passing through Bangpae from irrigation project located at nearby provinces. This enable farmers to plant corn or mungbean during the dry season in the field adjacent to the irrigation canal.

Base on twenty year average rainfall pattern (Figure D.1), rainy season at Bangpae generally starts in the middle of April. The amount of rainfall increase until it reach the peak of 110-120 mm. in June, drops in July and increase again in August, reach the second peak of 180 mm. in September, then decrease drastically in October. From December to early April, there was less than 10 mm. rainfall, therefore, crop growth after rice growing season is strictly dependant upon the amount of soil moisture left over after rice crop.

The amount and distribution of rainfall in 1977 was considerably poor compared to the normal year. A large amount of rainfall did not occur before June, while the peak rainfall appeared between late June to early September and drop drastically afterward. Drought occurred severely throughout the country therefore the crops suffered severely due to the lack of water.

D.1.2 Soil

Soil in Bangpae is generally alluvial deposit exhibiting a clayey texture with high water holding capacity and poor aeration. Soil samples taken from 71 locations displayed a remarkable difference in soil reaction and fertility. The soil pH ranged from 5.3-7.16. Organic matter level was 2.1-3.0 percent, available phosphorus and exchangeable potassium range from 20 to 60 ppm and 40-180 ppm, respectively.

D.1.3 Existing cropping pattern

There are three major crops grown in Bangpae namely rice, mungbean, and corn. Rice is exclusively grown in the rainy season while corn and mungbean are grown before and after rice crops. Growing corn and mungbean before rice are seldom practised by farmers unless rainfall in that particular season is adequate. Growing mungbean after rice is practiced by more farmers than growing corn. However, if rainfall in the particular season does not occur after rice these crops suffer tremendously due to moisture stress in the soil(Figure D.2).

D.1.4 Labor resource and farmers income

The average family number of Bangpae is 5.7 persons. Its breakdown for small, medium, and large farms are 4.38, 6.04, and 6.80 respectively. The average labor use per farm in terms of man-equivalents, for farm and non-farm work is 2.85 (Table D.1). The income of farmer covered in the study included farm and non-farm incomes. Farm income mainly consisted of revenue from two crops of the area, rice and mungbean. On the average, farm income constitutes 51% of the family income. The detailed breakdown of farmers income is shown in Table D.2.

D.2 Background of research conducted in 1977

It has been over a year since the Multiple Cropping Research Project of Kasetsart University started its research activity in the farmers' fields at Bangpae district, Rachaburi Province, Thailand. During this particular period, several experiments have been conducted and evaluated. The experiments that the project has conducted in the farmers' fields were grouped into two categories, cropping pattern experiments and component technology experiments. In addition, economic studies have been conducted to evaluate the input and economic feasibility of cropping pattern tested by the project in comparison to the normal cropping practiced by farmers.

D.2.1 Cropping pattern experiments

The cropping pattern experiments composed of several field crops experiments which had been conducted before and after rice growing season. It also included rice experiments using local rice varieties (photosensitive varieties) and recommended varieties (non photosensitive varieties). The prime objective of cropping pattern experiment is to identify the suitable cropping pattern that can be applicable and economically feasible to the farmer.

Within a year beginning April 1977, four field crops grown before rice, two rice varieties and five field crops grown after rice which make up 40 combination were tested under village condition (Table D.3). Out of 40 combination, M 7A variety of mungbean grown before and after recommended variety of rice appeared to be the most suitable among the system tested. The average yield of M 7 A mungbean grown before rice was 650 kg per hectare in our plots. Some of the farmers who grew local variety of mungbean could not harvest their crop; due to several problems, like more susceptability to insects and disease. Local variety of mungbean planted before rice yielded about 500 kg/ha. The yield of M 7 A mungbean grown after rice was 600 kg per hectare in our test. Farmers were able to obtain the same amount of yield when they used our variety. However, the yield of local mungbean variety grown by farmers was about 450 kg/ha. Severe drought which occurred last year affected other field crops either grown before or after rice, recommended variety of mungbean which are short in maturity appeared to tolerate and grow under limited moisture condition better than other crops. However, rainfall condition in 1977 was rare compared to normal year, therefore, there is a possibility that other cropping system may also be suitable under normal condition.

D.2.2 Components technology experiments

Components technology experiments are designed to study certain specific problems within a cropping season. Therefore, a component technology experiment which had been conducted before rice growing season may be different from those conducted during the period when crops were grown after rice. These experiments were fertilizer, insecticide, cultural practices, and weed control experiments.

Three mungbean and two corn experiments were conducted as part of component technology experiments before rice crop. Fertilizer and herbicide trials were tested using recommended and local rice varieties in rice growing season. During the season after rice, four mungbean, black gram and one crop of sweet corn, sweet potato and soybean were also studied as part of component technology experiments. The list of component technology conducted are shown in Table D.4.

The yield of corn and mungbean increased significantly in fertilizer treatments. However, fertilizer gave rise to better weed growth therefore severe weed competition occurred to crops. The application of pre-emergence herbicide in combination with fertilizer gave better weed control and higher crop yield. Regarding insect problems in mungbean, the use of Furadan for controlling beanflies damages and Phosdrin for leaf and pod attacking insects were shown to give quite satisfactory results. Planting mungbean in rows resulted in better crop stand, better weed control and higher seed yield. At present, number of data have been collected, analyzed and evaluated. The result of both cropping pattern and component technology will be presented in Multiple Cropping Research Project Annual Report 1977 available not later than August 1978. However several experiments in component technology will be reconducted to reconfirm the result that have already been obtained and to gather more beneficial information. As mentioned earlier, drought that occurred in 1977 affected all component technology so much so that crop performance data should be collected to compare the experiment result between normal and drought year.

D.2.3 Economic Studies

There were three categories of research activities which have been studied by economic component since the beginning of Multiple Cropping Research Project activities at Bangpae in late 1976. Firstly, a detail work on modification of the base-line survey. Secondly, a study on resource use in and returns to crop production of the cooperating farmers. Thirdly, a study on selected subjects in relation to crop production in Bangpae area.

D.2.3(1) Modification of the base-line survey

The base-line survey was done in 1976 covering three different possible research project sites of Bangpae, Khao Cha-ngoom, and Tungbua. A detailed elaboration on the application of base-line data was done for the Bangpae site in order to use it as a guide in the planning of research activities in the area and to be used as base-line data for evaluating the result of the project in the future. The main work concentrated, on relating the base-line data with the national standard data and interpreted them into the possible alternatives as appeared to be found in the Bangpae area.

D.2.3(2) A study on resource use in the returns to crop production of cooperating farmers

Data collection and analysis on resource use and returns to crop production was done for the three periods of April - July, July - January, and January - April. As of now, only the results of the first period had finished. They covered the patterns of the uses of land, family labor, draft animal labor, tractor and machine services, and modern farm production inputs. Its costs and returns on the production of selected crops of the 20 cooperative farmers were then analysed. It is hoped that the same type of work for period 2 and 3 would be completed very soon.

D.2.3(3) A study on selected subjects related to crop production

The work done in this part was primarily dealt with personal observation and informal discussions with the cooperating farmers and researchers themselves. It was aimed to gather relevant information for the use of researchers in agronomy and other related fields in planning and evaluating their research acitivities in the project area. The work has been concentrated on the following subjects.

a. A study on economics of the use of farm machinery in farming

b. A study on the attitudes of cooperators towards the application of modern inputs and technologies, and

c. A study on the spread effects of the research work.

Most of the work of the above subjects are underway. Some studies just started collecting information. Some subjects are ready for the analysis. It is hoped to continue and finish working on these subjects in 1978.

E. Other Cropping Systems Research

In Thailand, many different groups are conducting research which could be defined as cropping systems research.

Chiengmai University has been conducting cropping pattern trials for 8 years and have put out over 40 publications. Their methodology has been based on developing a total package in the station and then taking it out to the farmers.

Khonkaen University has been conducting cropping pattern trials in farmers fields for 4 years and have over 10 publications.

In addition, each of the regional research centers has been conducting some work on cropping patterns. The Department of Agriculture has studied on intercropping and relay interplanting in corn, sugarcane, cassava, rubber, coconut, and, orchard crops. The East-West Centre's Cropping Systems Program is working with Kasetsart University on the

effect of legume crops in rotations. A number of bilateral aid programs are found in many parts of the country conducting some research on cropping patterns. The following brief summary of research highlights from various organizations in Thailand is meant only to give an indication of the type of work being conducted in the different regions of the Kingdom. All results reported are from the Proceedings of the First National Seminar on Cropping Systems, July 11-14, 1977.

During the rainy season, 13% of the cultivated land in the Northeast of Thailand is not planted to any crops while, for all of Thailand, the figure is 22%. There is a great reverse of labor even in the busiest month of July, 38.5 of the agricultural labor force was unemployed that month. Farmers supplied only 25% of the capitalused in the cultivation of crops. The remaining 72% was supplied by a variety of agencies. Thus, new technology should be aimed at increasing the use of land and labor, p.1-24.

The Northeast

In the Northeast where an upland crop is to be grown before rice, it has been found the latest that the first crop should be harvested in the end of August, p. 51. One of the main reasons for so much idle land in the Northeast is that farmers are only able to plant rice on the upland areas one year out of five. Switching these fields to upland cropping patterns may help the farmer the most, p. 73. Many agencies have tried sorghum with limited success due to bird damage, poor stands, and, some management problems, p. 83, 56, 49.

Phosphorous levels are low in most soils of the Northeast. In Sansai soils, 9 ppm. extractable P is sufficient for rice production. Analysis of P in leaf sheath at 45 DAT can establish the critual level of P for rice, p.190. Intercropping with cassava appears to have some potential but the management of the second crop is still not solved, p. 241. It was found that cassava and other crops were not consistently responding to fertilizer and the high variability of yield made their production a high risk venture, p.243. Intercropping legumes with kenaf has not paid due to very low legume yields, p.291. In the irrigated areas of the Northeast liming was not found to pay and the use of herbicides was no better than hand weeding, p.348. It was noted that cropping patterns that gave high net returns had high total costs, p.389. This indicates the use of capital intensive technology.

The North

In nitrogen trials on cropping patterns in the mountains of the North, there was no response due to the high levels of organic matter soil phosphorous and potash, p. 92. In a series of fertilizer trials in the North, three crops were grown in sequence with only the first receiving fertilizer. The second crop of soybeans responded to residue P_2O_5 and K_2O. The third crop of sweet corn showed no significant effect. The second crop of mungbean responded to

residue nitrogen and P_2O_5, p. 153-176. In those areas currently having irrigation and growing two crops, mungbean appeared to have the most potential for a third crop but the rest problem must be solved, p. 226. An additional problem of soybean and peanut is lack of good seed, p.364. Small farmers were found to be more commercially oriented than larger farmers who culd rely on our production for food needs, p.461.

Central

It was found interplanting mungbean and soybean in sugarcane did not affect yield of sugarcane but yields of legumes were very low, p. 380. Soybeans, sweet corn, cotton, and, peanuts have been found to be the most suitable crops in rice based cropping patterns, p. 39.

The South

In the South, in certain areas the population pressure on land is forcing land-holdings down to 1.5 ha of rainfed land. The people rather than grow a second crop are going into the forest for slash and burn agriculture, p.425. Those with irrigation find it is unreliable, p.425.

F. Training

From 1971 to 1978, 28 Thai participants have been enrolled in the IRRI cropping systems training courses. The majority of the trainees came from the Department of Agriculture with some from Kasetsart University. Upon the completion of their trainings, most of them returned to their previous respective fields of work and involved in the on-going cropping systems programs. Trainees from the Rice and Technical Divisions of the Department of Agriculture will participate fully in the cropping systems work. They became coordinators and/or technicians at the research sites. People from component technology disciplines such as entomology and plant pathology usually devote some of their times to help supervising the component researches at the sites. Nevertheless, the returned trainees help in some ways or others to carry out the cropping systems research and development work. In addition, the Thai programs sent six persons to study at UPLB with IRRI cooperation for graduate studies in agronomy and agricultural economics. Also seven research workers have been granted IDRC scholarships to receive academic trainings both at the B.S. and M.S. levels within the country. It is important that in order to achieve a successful cropping systems program, competent, hard-working and well-trained people must be acquired through intensive trainings in the short-course ones as well as in the academic category. So that the training component must be further carried on until the requirement has been fulfilled which will take a considerable period of time.

II. 1979-1981 Plans

Objectives

A. To strengthen the coordinated cropping systems research program and to develop effective operational procedures for this type of research.

B. To develop cropping systems technology for rainfed and partially irrigated rice areas by (1) evaluation of established cropping systems and (II) improvement of these cropping systems through agronomic and economic research on farmers' fields.

C. To demonstrate and evaluate the cropping systems developed on farmers' fields.

D. To train Thais in the methods of cropping systems evaluation and development.

E. To develop cropping systems concepts applicable to Thailand.

Methodology

1. Detailed study of cropping systems will be continued. Since 1977 was so dry, data is of limited value in understanding what usually happens.

1979 - Continued at Pimai and Ubon and Bangpae, Inburi stop. Work begin at Kampangpet.

1980 - Possibly stop Pimai and Ubon. Work start at other potential sites.

1981 - Kampangpet and other sites.

In place of detailed studies special studies to answer specific problems will be used as the program moves away from descriptive research. At present it appears cash, management and probably marketing will be the priority study areas.

The data collected for this work will also be used in helping the National Policy Board establish guides for the future.

In 1981, it is expected that work on farming systems may be possible. This would include interaction of power and sources of farm work with cropping systems. The work on combining cropping patterns to form a cropping system would also be under study by 1981.

2. Cropping Pattern Trial

1979 - Continuation of promising cropping patterns trials at all four sites. It is likely that several new pattern will be tried to meet different environmental factors, such as, soil moisture conditions. It is also likely that the patterns will be tested on a greater number of farmers fields to test stability. The crops that will be considered in the pattern trials are rice, mungbean, cowpea, soybean, yardlong bean, corn, peanut, sweet-potato, cassava, sesame, melon type crops, black gram and kenaf. The major emphasis though is on rice and legume crops.

1980 - This year should supply the final confirmation on the patterns. It is likely that the patterns will be grown on many farmers' fields as a final check with a limited amount of data collected. The patterns would be supervised by extension trainees who are becoming familiar with the proposed patterns.

1981 - The final year would be to confirm the environmental limits of the proposed pattern so extension personnel can be guided as to its range. This will also serve as a basis for deciding on the next environmental area to be worked on in detail.

Table A.1. Results of cropping pattern trials in farmers' fields at the Ubon site, 1977-78 crop year.

Pattern	Crop variety	Farmer		Planting M/D/Y	Spacing cm	Fert. kg/ha $N-P_2O_5-K_2O$	Harvesting days	Yield kg/ha
1	Yard long bean - Local	1		5/16/77	50 x 100	25-31.25-25	56-98	6,644
		2		5/9/77	"	"	78-105	5,300
		3		6/8/77	"	"	-	flood damage
	Transplanted rice - NSPT	1		9/10/77	25 x 33	25+25-31.25-25	139	1,775
		2		9/13/77	"	"	141	1,087
		3		-	-	-	-	-
2	Direct or transpl. rice - RD6	1	T	8/10/77	25 x 35	25+25-31.25-25	158	1,156
		2	D	5/10/77	33 bet. row	"	189	2,562
		3	D	5/17/77	"	"	183	2,825
	Cowpea - Local	1		11/29/77	25 x 33	25-31.25-25	91	312
		2		12/2/77	"	"	78	1,050
		3		11/30/77	"	"	89	1,287
3	Direct rice - RD-9	1		5/10/77	33 bet. row	25+25-31.25-25	136	3,612
		2		7/6/77	"	"	109	1,387
		3		5/16/77	"	"	-	bird, rat damage
	Glutinous Corn - Local	1		11/6/77	25 x 100	50-50-25	88	25,000 ears/ha
		2		11/19/77	"	"	73	36,562 "
		3		11/9/77	"	"	85	8,750 "
4	Direct. rice - RD-7	1		7/1/77	33 bet. row	25+25-31.25-25	126	1,287
		2		7/4/77	"	"	124	3,125
		3		5/7/77	"	"	149	3,750
	Peanut - Lampang	1		11/12/77	25 x 33	25-31.25-25	-	drought damage
		2		11/18/77	"	"	101	1,075
		3		11/20/77	"	"	101	1,131
5	Direct rice - DMI 6646	1		5/26/77	33 bet. row	25+25-31.25-25	130	2,206
		2		5/11/77	"	"	-	nematode damage
		3		5/18/77	"	"	-	
	Transplanted rice - HY 71	1		10/15/77	25 x 33	25+25-31.25-25	98	550
		2		10/3/77	"	"	-	-
		3		-	-	-	-	-

Table B.1. Average yield of 2 farms of mungbean and 1 farm of rice at 7 rates of fertilizer application, Pimai site 1977 wet season.

Trt.	Fertilizer rate kg/ha $N-P_2O_5-K_2O$	Mungbean yield kg/ha	Rice yield kg/ha
1	0-0-0	403	3275
2	31.25-31.25-31.25	475	2075
3	62.5-62.5-62.5	537	2719
4	93.75-0-0	387	2762
5	93.75-0-93.75	325	2837
6	93.75-93.75-0	662	3025
7	93.75-93.75-93.75	587	2781

ANOV Mungbean

Among farm <1

Traatment

Trtx Farm*

C.V. = 17%

Differences

N effect (P=0, K=0) 206*

P effect (N=93.75, K=0) 731**

(N=93.75, K=93.75) 287*

K effect (N=93.75, P=93.75) -275*

ANOV Rice

Treatment n.s.

C.V. 3.5%

Table B.2. Average yield of 3 farms of peanut and 2 farms of rice at 7 rates of fertilizer application, Pimai site 1977 wet season.

Trt.	Fertilizer rate kg/ha $N-P_2O_5-K_2O$	Peanut yield kg/ha	Rice yield kg/ha
1	0-0-0	2356	3347
2	31.25-31.25-31.25	2731	3609
3	62.5-62.5-62.5	2912	3775
4	93.75-0-0	2806	4225
5	93.75-0-93.75	2712	3962
6	93.75-93.75-0	3294	4381
7	93.75-93.75-93.75	2531	4141

ANOV Peanut

Among farm**

Treatment*

Trt x Farm $^{n.s.}$

C.V. = 10%

ANOV Rice

Among farm**

Treatment $^{n.s.}$

Trt x Farm $^{n.s.}$

C.V. = 11%

Differences

N effect (P=0, K=0) $450^{n.s.}$

P effect (N=93.75, K=0) 494*
(N=93.75, K=93.75) $181^{n.s.}$

K effect (N=93.75, P=93.75) -762*

Table B.3. Average yield of 2 farms of glutinous corn and 1 farm of rice at 7 rates of fertilizer application, Pimai site 1977 wet season.

Trt.	Fertilizer rate kg/ha $N-P_2O_5-K_2O$	Corn yield ear/ha	Rice yield kg/ha
1	0-0-0	4934	3650
2	62.5-62.5-62.5	6066	3837
3	125-125-125	5833	4044
4	187.5-0-0	4533	4025
5	187.5-0-187.5	5066	3987
6	187.5-187.5-0	5200	3581
7	187.5-187.5-187.5	6767	3500

ANOV Corn

Among farm$^{n.s.}$

Treatment <1

Trt. x Farm <1

C.V. = 33%

ANOV Rice

Treatment <1

C.V. = 21.40%

Table B.4. Average yield of 1 farm of cucumber and 1 farm of rice at 7 rates of fertilizer application, Pimai site, 1977 wet season.

Trt.	Fertilizer rate kg/ha $N-P_2O_5-K_2O$	Cucumber yield kg/ha	Rice yield kg/ha
1	0-0-0	4531	2100
2	31.25-31.25-31.25	6212	2015
3	62.5-62.5-62.5	7487	865
4	93.75-0-0	3350	869
5	93.75-0-93.75	6925	844
6	93.75-93.75-0	8900	1737
7	93.75-93.75-93.75	4875	2250

ANOV Cucumber

Treatment$^{n.s.}$

C.V. = 23%

ANOV Rice

Treatment$^{n.s.}$

C.V. = 17%

Table B.5. Average yield of 2 farms of glutinous corn + mungbean intercrop and 2 farms of rice at 7 rates of fertilizer application, Pimai site 1977 wet season.

Trt.	Fertilizer rate kg/ha $N-P_2O_5-K_2O$	Corn yield ear/ha	Mungbean yield kg/ha	Rice yield kg/ha
1	0-0-0	8331	372	2700
2	62.5-62.5-62.5	20000	416	3256
3	125-125-125	30838	484	3356
4	187.5-0-0	29169	403	3466
5	187.5-0-187.5	30000	278	4347
6	187.5-187.5-0	35412	394	4216
7	187.5-187.5-187.5	32500	434	3816

<u>ANOV Corn of 1 farm</u>

Treatment$^{n.s.}$

C.V. = 24%

<u>ANOV Mungbean</u>

Among Farms <1

Treatment <1

Treatment x farms <1

C.V. = 35%

<u>ANOV Rice</u>

Among Farms$^{n.s.}$

Treatment$^{n.s.}$

Trt. x farm$^{n.s.}$

C.V. = 14%

Table B.6. Pimai fertilizer costs and returns 1977[1/]

Fertilizer rate	Fertilizer cost	Additional Income			Residual effect on rice	Additional Income Minus Fertilizer Cost (฿/ha)		
		Peanut	Mungbean	Cucumber		Peanut rice	Mungbean rice	Cucumber rice
0 - 0 - 0	0							
31.25-31.25-31.25	1300	388	375	538	162	-750	-763	-600
62.5-62.5-62.5	2606	1544	862	946	12	-1050	-1732	-1648
93.75-93.75-93.75	3912	100	1200	110	500	-3312	-2212	-3302
93.75 - 0 - 0	1219	1906	-225	-378	212	899	-1232	-1385
93.75-93.75 - 0	3112	1706	1650	1398	488	-918	-974	-1226
93.75 - 0 - 93.75	2012	1138	-375	-266	0	-874	-2387	-1246

		Corn	Corn/ Mungbean	Residual effect on rice	Corn Rice	Corn/Mungbean Rice
0 - 0 - 0	0					
62.5-62.5-62.5	2606	2475	5256	12	-119	2662
125-125-125	5212	1962	9062	712	-2538	4562
187.5-187.5-187.5	7819	3981	7956	1181	-2650	1325
187.5 - 0 - 0	2438	-881	2244	688	-2631	494
187.5-187.5 - 0	6224	681	4644	1662	-3881	82
187.5 - 0 - 187.5	4024	288	4106	1362	-2347	444

1/ Value used in Baht

N = 13/kg K_2O = 8.5/kg Mungbean = 6/kg Corn = 0.35/ear

P_2O_5 = 20.2/kg Rice = 2/kg Peanut = 3.25/kg Cucumber = 2/kg

1 U.S.$ equivalent to about ฿20.00

Table B.7. Cropping systems study under rainfed condition at Pimai Rice Experiment Station, 1977 wet season.

Cropping pattern	Crop variety	Planting	Spacing cm	Fert. kg/ha $N-P_2O_5-K_2O$	Harvesting days	Ave. yield kg/ha
1	Mungbean-M7A	5/25/77	10 x 50	31.25-62.5-62.5	67	405
	Rice-KDML 105	Transpl. 9/8/77	25 x 25	25 + 31.25 - 37.5-37.5	114	2,619
2	Peanut-Lampang	5/25/77	10 x 50	31.25-62.5-62.5	102	1,364
	Rice RD-15	Transpl. 7/8/77	25 x 25	25 + 31.25-37.5-37.5	112	3,387
3	Cucumber-Local	5/25/77	100 x 100	31.25-62.5-62.5	56	14,875
	Rice RD-6	Transpl. 9/8/77	25 x 25	25 + 31.25-37.5-37.5	122	2,869
4	Glutinous corn corn-local	5/25/77	50 x 100	62.5-62.5-62.5	67	15,625 ears
	Rice-RD7	Transpl. 9/8/77	25 x 25	25 + 31.25-37.5-37.5	129	3,037

ANOV Rice

Treatment*

C.V. = 17%

L.S.D. 5% 506 1% 766

Table C-1. Existing average resources per farm.

Land (rai)*						Capital (baht)	Man Power (man)	
For holding	Housing area	Paddy field	Field crops	Orchard	Others	Money saving	Permanent labor	Temporary labor
32.89	0.88	31.42	0.25	0.20	0.14	2,028.82	2.59	0.99

* One rai is equal to 1600 sq.m. or 0.16 ha.

Table C-2. Resource utilization per farm.

Land			Capital			Labor (for agricultural purpose)		
	Rai	Percentage		Baht	Percentage		Hour	Percentage
Farm holding used for crop production	32.00	100	-Total expenses	8,423.70	100	Total man power	2,412.85	100
Transplanted rice (Monsoon season)	12.68	39.62	-Seed	437.70	5.16	Household man-power	1,300.82	53.91
Broadcasted rice (Monsoon season)	18.73	58.51	-Fertilizers	275.10	3.27	Exchanged man-power	314.87	13.05
Upland crops	0.25	0.78	-Pesticides	187.75	2.23	Hired labor	797.16	33.04
Vegetable	0.02	0.06	-Fuel	157.91	0.87			
Orchard	0.33	1.03	-Man power	2,382.22	28.28	Animal power	168.90	-
Second crops after rice	2.92	9.12	-Animal power	20.87	0.25	Mechanical power	46.86	-
			-Machinery	1,643.17	19.51			
			-Land Tenant	3,231.88	38.36			
			-Land duty	90.09	1.07			
Total planting area in one year	34.93	109.12						

Table C-3. Yield production of RD5 rice variety, groundnut and sweet corn at Inburi in the crop year 1976/77.

No. of farmer	Yield of RD5 (kg/rai)	Groundnut (shelled) (kg/rai)	Sweet corn (ear/rai)
1	735.114	482.23	4984
2	787.648	386.78	-
3	762.295	340.30	4975
4	739.025	224.33	-
5	826-629	367.69	3911
6	728.155	302.12	4500
7	761.649	-	4043
8	706.649	-	-
9	845.388	-	4419
10	765.900	-	7771
11	776.420	-	3916
Average	766.81	350.575	4814.8

Table C-4. Variable inputs, production and net income above variable input per rai of the tested system (within the project).

Description	RD5 Rice		Groundnut		Sweet Corn		Total price (Baht)
	Amount	Price (Baht)	Amount	Price (Baht)	Amount	Price (Baht)	
1. Total yield production (kg)	366.80	1,712.47	350.84	1,694.14	4,815 ear	2,343.34	5,749.95
2. Variable Cash input	-	301.71	-	643.33	-	430.02	1,375.06
- Seeds (kg)	3.88	9.62	25.43	393.71	2.87	47.53	-
- Fertilizers(kg)	34.00	123.00	40.00	175.00	83.00	278.50	-
- Pesticides Sevin (gm)	26.70	2.50	30.00	2.76	95.00	8.75	-
- Azodrin (c.c)	31.00	6.20	178.00	35.60	154.00	30.80	-
- Man labour wages (hr.)	44.83	91.90	-	-	7.23	20.02	-
- Mechanical cost (hr.)	0.83	35.12	1.43	14.41	-	-	-
- Fuel cost	10.48	33.37	9.09	21.85	12.00	44.42	-
3. Non-cash variable input	-	393.40	-	406.64	-	549.86	1,349.90
- Self-seed (kg)	10.29	23.33	-	-	-	-	-
- Self-labor (hr)	106.70	218.10	109.00	282.71	155.67	389.17	-
- Self-mechnical power (hr)	14.53	134.29	7.24	85.60	14.52	134.89	-
- Self-animal power (hr)	7.60	17.68	9.54	38.33	2.47	25.80	-
4. Total variable input (2+3)	-	695.11	-	1,049.97	-	979.88	2,724.96
5. Net income above total variable input (1-4)		1,017.36	-	644.17	-	1,363.46	3,024.99

RD5 Rice - Groundnut - Sweet corn
Crop Year - 1976/77
Location - Inburi Sub-district, Inburi District, Singburi Province

Remarks:

1. Fertilizer Use

Rice 6-4-0 kg/rai of Ammonium phosphate (16-20-0) for 20 kg.; 40.50 baht/kg
Ammonium sulphate (20% N) for 14 kg; 3 baht/kg

Groundut: 4.8-6-6 kg/rai of Ammonium phosphate (16-20-0) for 30 kg; 4.50 baht/kg
Potassium chloride (60% K20) for 10 kg; 4 baht/kg

Corn 12-12-6 kg/rai of Ammonium phosphate (16-20-0) for 60 kg; 4.50 baht/kg
Ammonium sulphate (20% N) for 12 kg; 3 baht/kg
Potassium chloride. (60% K_2O) for 10 kg; 4 baht/kg

2. Capital without opportunity cost

Table C-5. Comparative study of production, cost and returns per rai both before the introduction of the project and during the time of the project.

Crop types	Yield		Price (baht)		Total variable inputs (baht)		Net income above variable inputs (baht)	
	1/	2/	1/	2/	1/	2/	1/	2/
Paddy rice (kg)-RD5	441.0	766.8	992.3	1,712.5	502.7	695.1	498.6	1,017.36
Groundnut (kg)	337.7	350.6	1,631.0	1,694.1	814.5	1,050.0	816.5	644.2
Corn (ear)	2,400.0	4,815.0	1,200.1	2,343.2	415.6	979.9	784.4	1,363.5
Total Net Income							2,090.5	3,025.0

1/ Before the introduction of the project-entirely practiced by the farmers themselves.

2/ During the time of the project - researchers adviced and supervised cooperatively with farmers.

Table D.1. Average family member and man-equivalents (M.E.) per farm by farm size 1975.

Farm size	Average family member	Average M.E. per farm		
		for farm work	for non-farm work	Total
(1)	(2)	(3)	(4)	(5)
Small	4.38	1.38	0.68	2.06
Medium	6.04	2.70	0.48	3.18
Large	6.80	2.94	0.23	3.17
All size	5.73	2.37	0.48	2.85

Table D.2. Family income by farm size 1975.

Farm size	Income (฿ per farm)			Average income per family member
	Farm	Non-farm	Total	
(1)	(2)	(3)	(4)	(5)
Small	1,416	16,416	17,831	4,071
Medium	11,667	9,685	21,352	3,535
Large	24,272	7,350	31,622	4,650
All size	11,507	11,110	22,617	3,947

Table D.3. List of field crops and rice grown at specific cropping season in cropping pattern experiments.

Crop before rice April - July	Specific Cropping Season Rice crop August - November	Crop after rice December - March
Mungbean (M7A)	Rice (recommended var.)	Mungbean (M7A)
Mungbean (local var)	Rice (local var.)	Black gram
Sweet corn		Sweet corn
Glutinous corn		Glutinous corn
		Soybean

Table 4. List of component technology experiments conducted at particular cropping season by the multiple cropping project.

Crop	Experimental description
← Crop before rice →	
Mungbean	Method of planting and fertilizer use
Mungbean	Insecticide trial
Mungbean	Hormone application
Glutinous Corn	Fertilizer trial
← Rice crop →	
Rice (local var.)	Pre emergence herbicide trial in direct seeding rice
Rice (local var.)	Post emergence herbicide trial in direct seeding rice
Rice (local var.)	Weed control in transplanted rice
Rice (local var.)	Fertilizer trial
Rice (recommended var.)	Fertilizer trial
← Crop after rice →	
Mungbean	Land preparation experiment
Mungbean	Insecticide trial
Mungbean	Hormone trial
Mungbean	Weed control experiment
Mungbean	The effect of different cultural practices in mungbean upon residue soil moisture
Black gram	Land preparation experiment
Black gram	Insecticide trial
Sweet corn	Straw mulching
Glutinous corn	Straw mulching
Soybean	Straw mulching
Sweet potato	Straw mulching

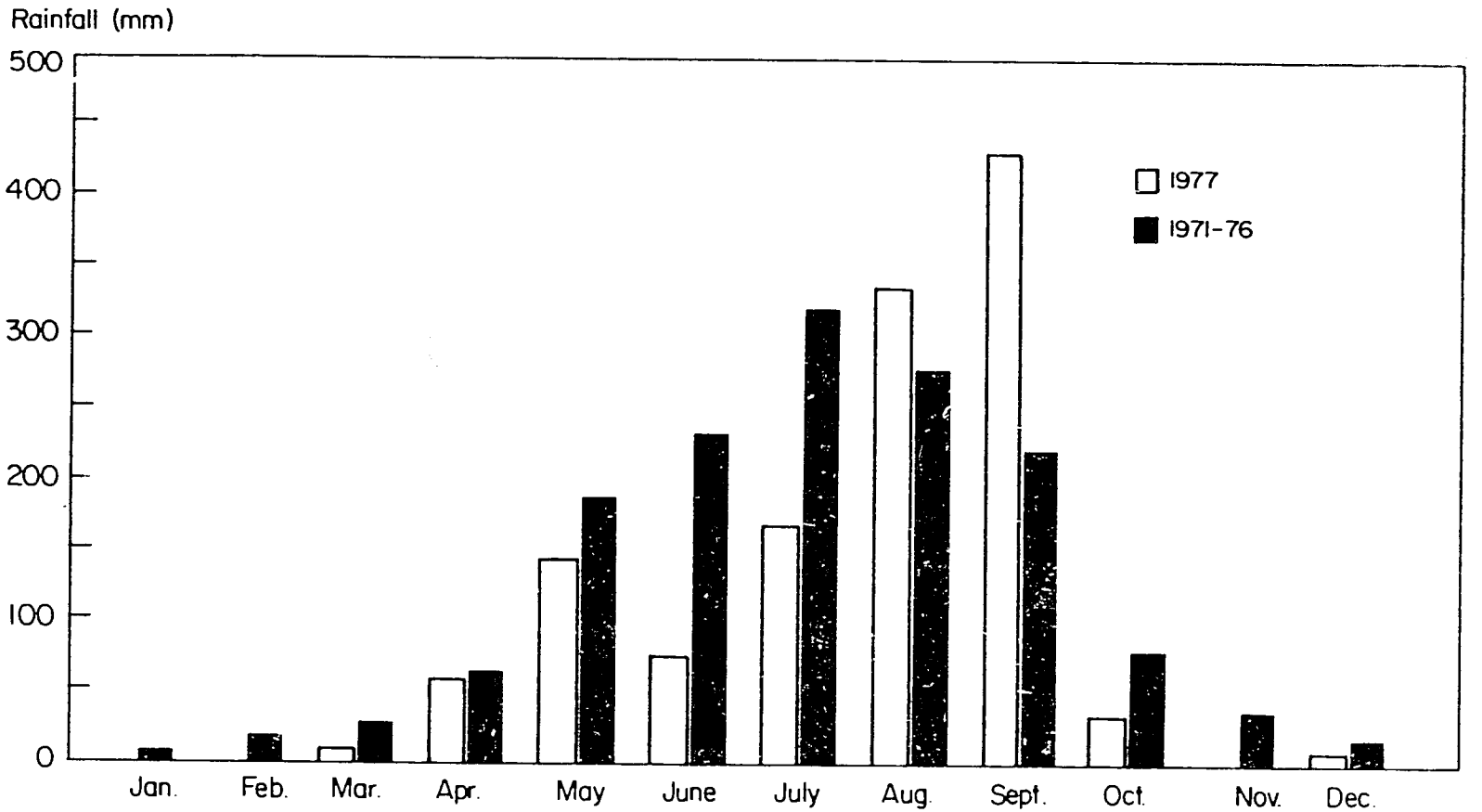

Fig. A.1. Average monthly rainfall at Moeng District, Ubonratchathani Province during 1971-76 and in 1977.

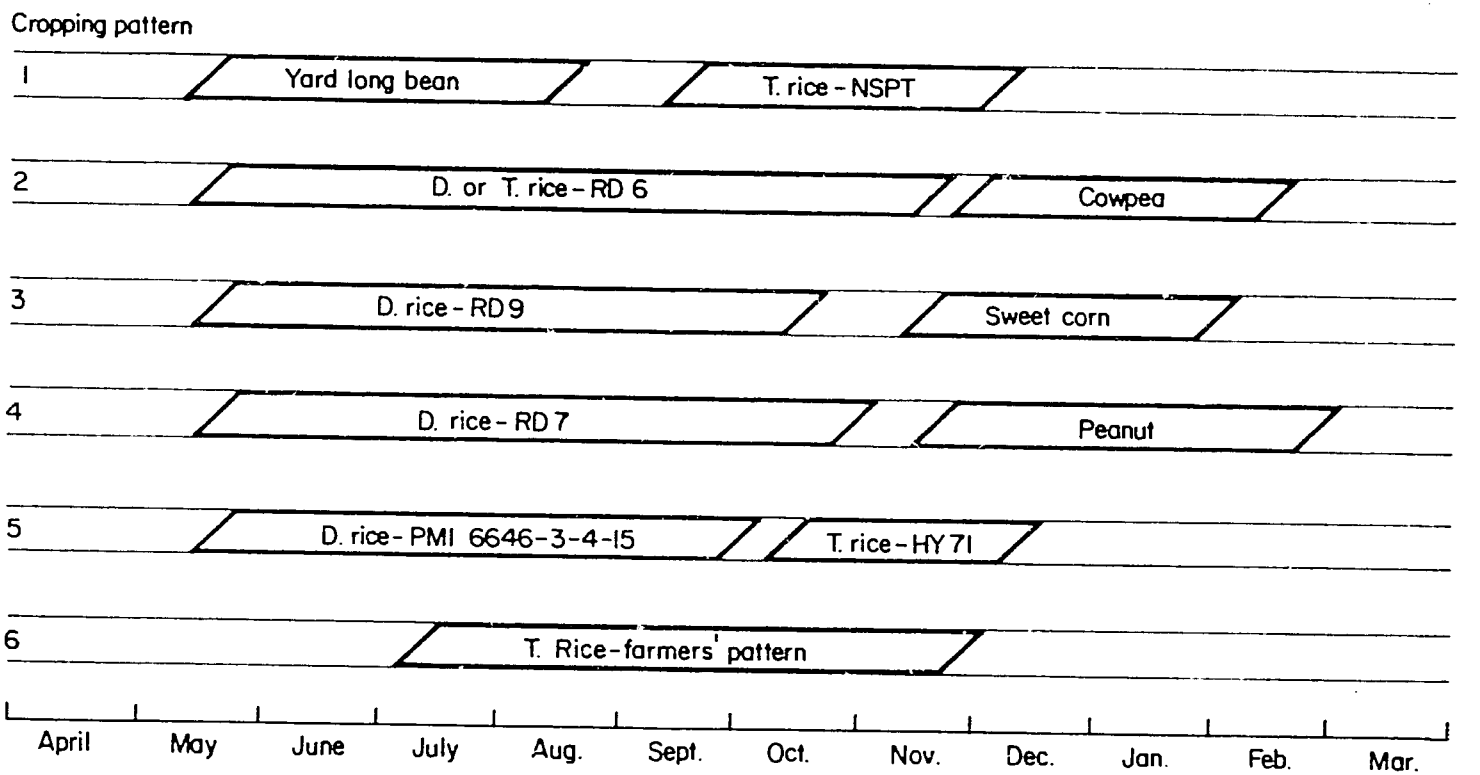

Fig. A.2. Rainfed cropping pattern trials in farmers' fields at Ubon site in 1977-78.

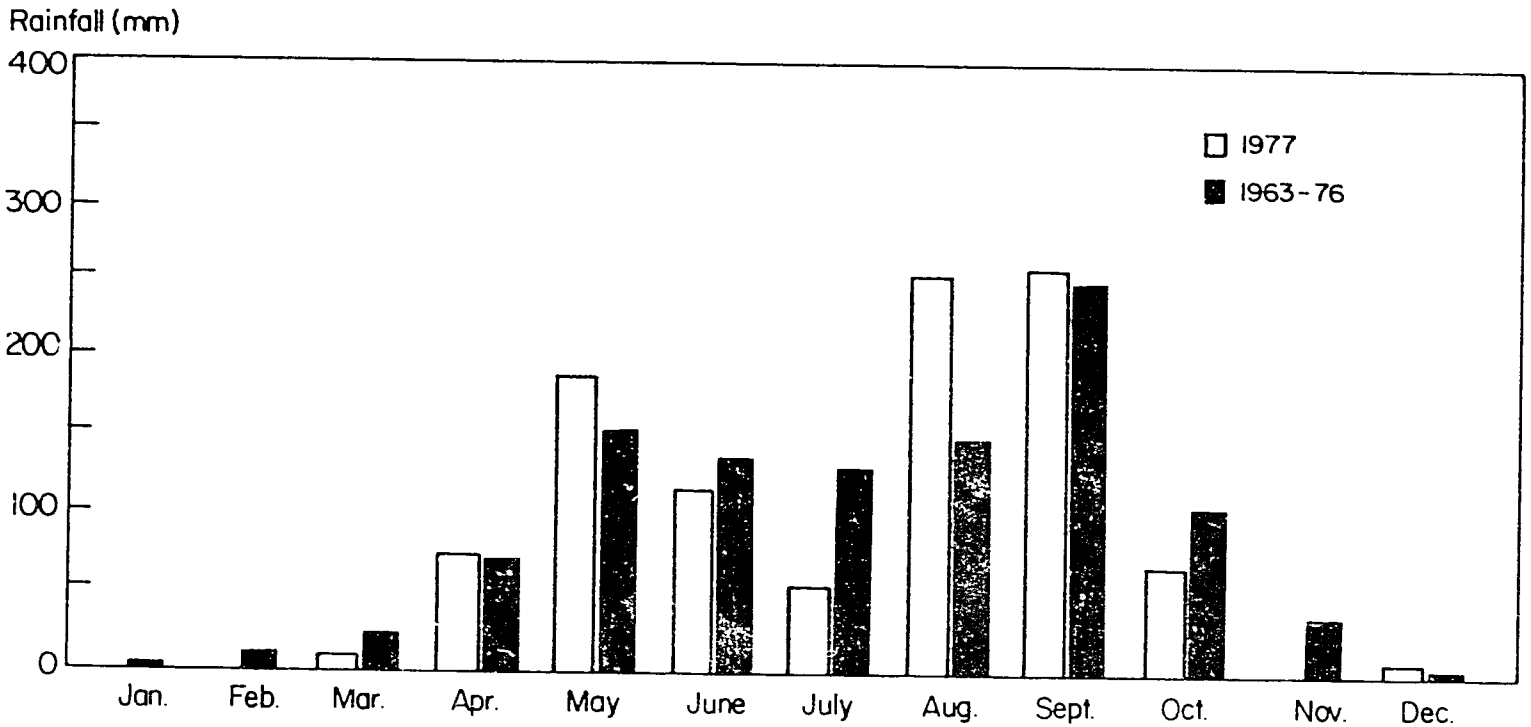

Fig. B.1. Average monthly rainfall at Pimai Rice Experiment Station during 1963-76 and in 1977.

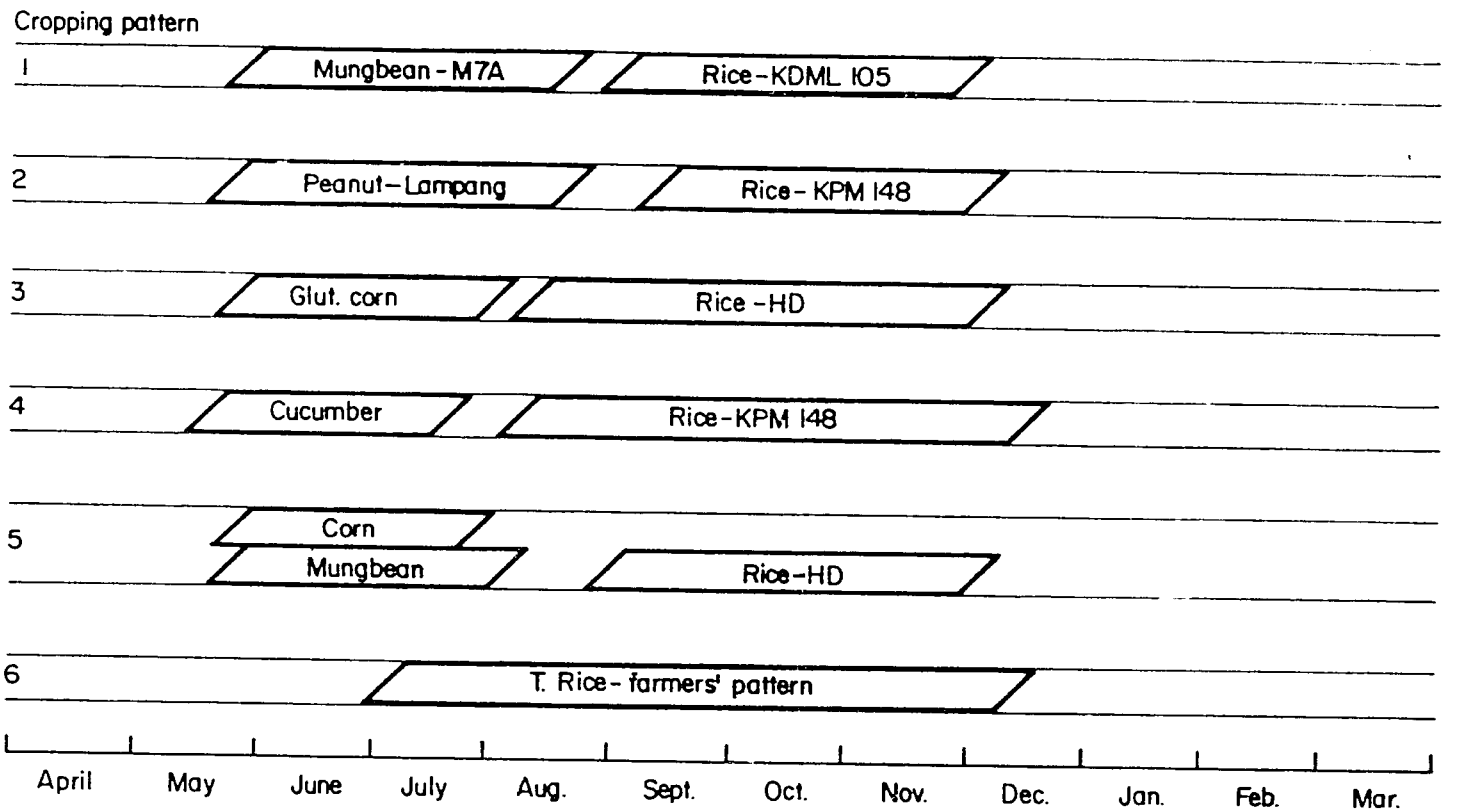

Fig. B.2. Rainfed cropping pattern trials in farmers' fields at Pimai site in 1977-78.

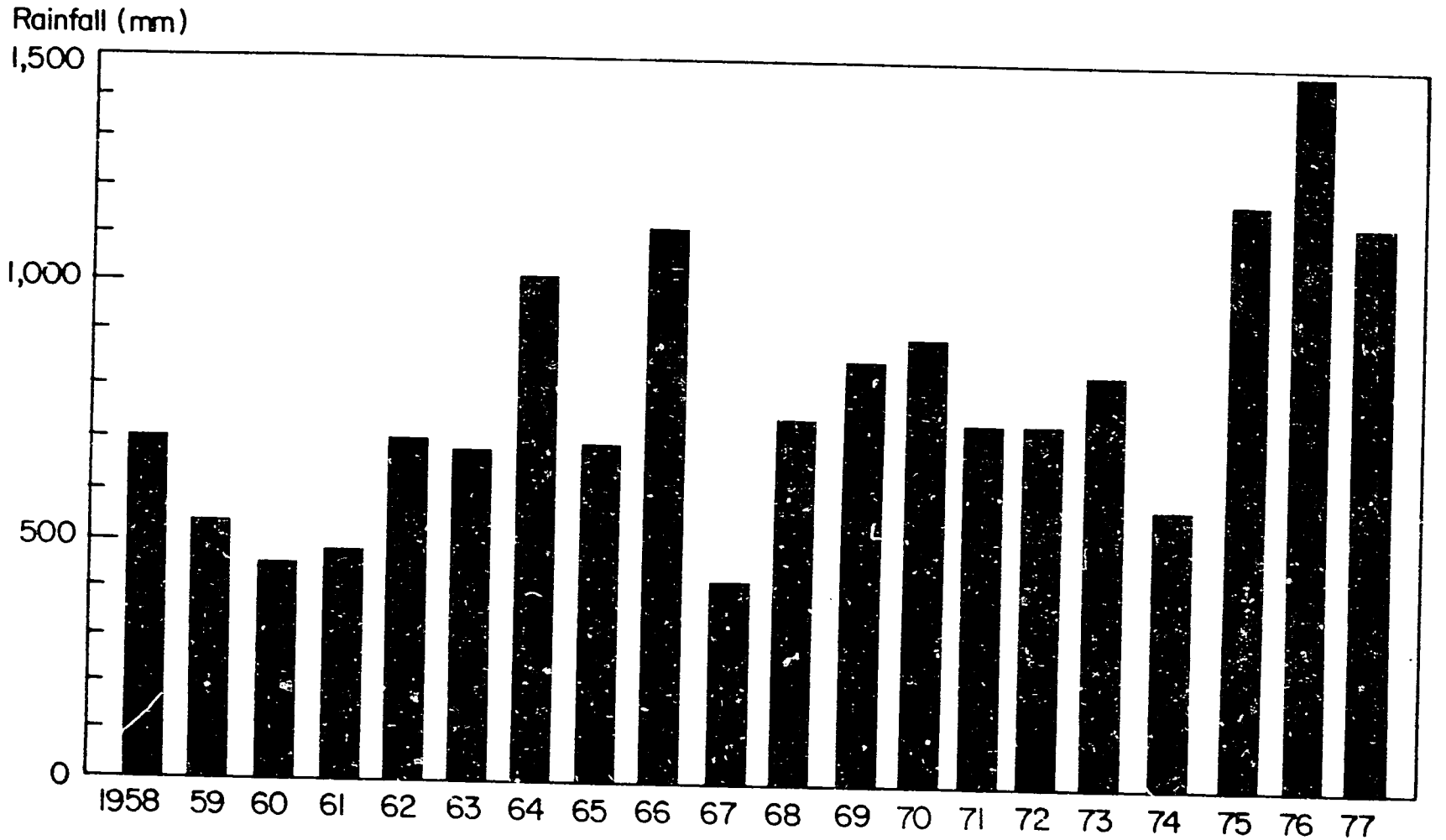

Fig. D.1. Twenty-year average total rainfall (1958-1977).

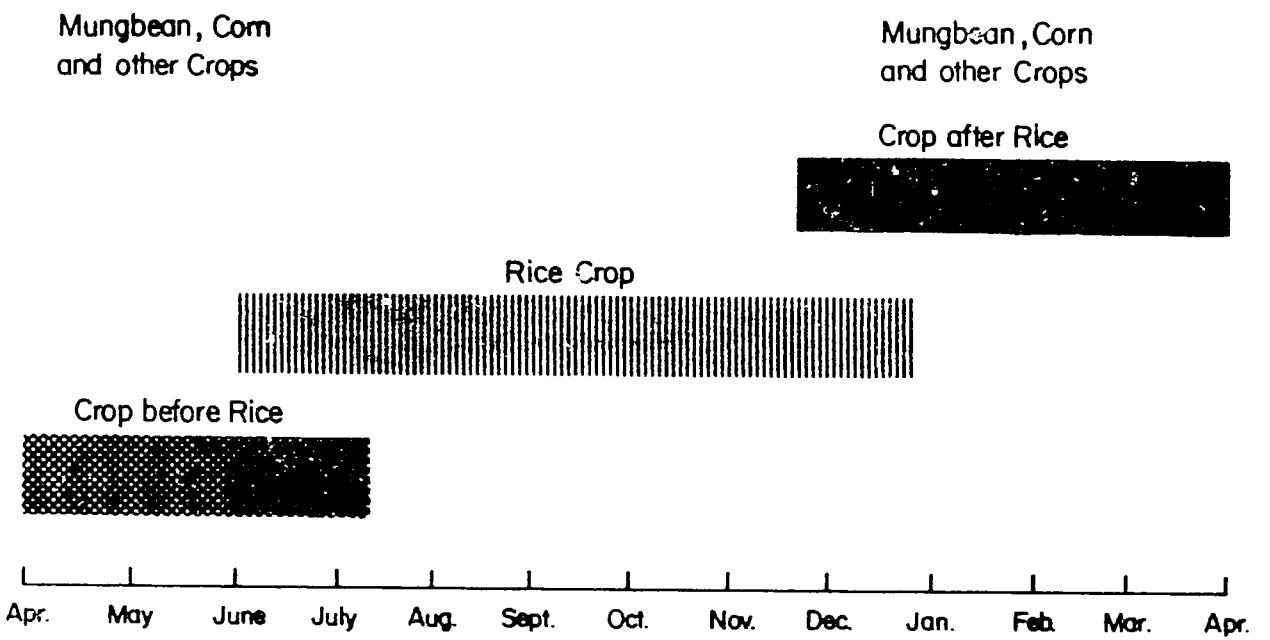

Fig. D.2. Existing cropping patterns commonly practiced by farmers at Bangpae.

MINISTRY OF AGRICULTURE AND COOPERATIVES

Department of Agriculture

- Rice Division*
- Field Crops Division
- Horticulture Division
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8 Other Departments

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- College of Agriculture*
- College of Economics & Business Administration*
- College of Forestry
- College of Arts and Science
- College of Engineering
- College of Education
- College of Veterinary Science
- College of Social Science
- College of Fishery
- Graduate School

22 Other Universities

Organizational charge of the departments within the Ministry of Agriculture and Cooperatives and Kasetsart University which directly involve in the cropping systems research and development programs.

SRI LANKA CROPPING SYSTEMS PROGRAM UPDATE OCTOBER 1978

G.W.E. Fernando[1/]

Introduction

Since the last working group meeting hosted by Sri Lanka in December 1977 the Sri Lanka Cropping Systems program has evolved its organization structure to strengthen the economic component and expanded the scope of the effort both in terms of number of sites, the degree of effort at the newer sites, and the staff actively involved in cropping systems work. In the process the program has gained increased insight in how technology must adopt to variation in physical environment both in time and space. Likewise our economic analysis has began to highlight what economic factors are contributing to crop intensification and what can be done to encourage farmers to intensify their activities.

Organization Changes

Organizationally the biggest change was the inclusion of the Department of Agriculture's Economic Division as an active participant to handle the economic analysis. This gained the program the services of Dr. Nimal Ranaweera, Senior Agricultural Economist. He has subsequently assigned two members of his division to conduct the economic studies at Bandarawela and Paranthan as well as assisting the Economist at M.I. with the Walagambahuwa and Katupota analysis, and prepared a general outline for future Cropping Systems Economic Studies (Appendix A).

[1/] Deputy Director (Research and National Cropping Systems Coordinator.
The author wish to acknowledge the efforts of all past and present members of the Cropping Systems Program whose research has contributed to this report. This includes S. Upasena, R.O. (Agronomist), M.I.; N. Ranaweera, Senior Agricultural Economist; M. Sikurajapathy, former R.O. (Agronomy), M.I. currently on study leave; T. Senaratna, R.O. (Agronomy), Walagambahuwa; S. Mahendrarajah, R.O. (Economics), Walagambahuwa and Katupota; A. Senthinathan, R.O. (Agronomy), Paranthan; S. Sritharan, A.I.(Economics), Paranthan; J. Wahab, R.O. (Agronomy), Bandarawela; N. Weralugolla, E.A., Bandarawela; R. Seneviratne, R.O. (Agronomy), Mahaweli; M. Silva, R.O. (Agronomy), Angunakolapellesa; S. Thirianathan, R.O. (Agronomy), Mannar. Also the author would like to express his appreciation for the assistance provided by G. Banta, IDRC Economist and R. Tinsley, IRRI Agronomist.

Other organizational changes include the departure of Mervyn Sikurajapathy, who has assisted with the coordination of the program from its onset, for Ph.D studies at North Carolina State University. He has been replaced by Dr. S. Upasena who returned to Sri Lanka a year ago after completing his PhD in soil fertility at the University of Novisad in Yugoslavia. Before going for his PhD studies he was directly responsible for the Multiple Cropping Program out of which the Cropping Systems Program evolved, and work with Dr. Bradfield at IRRI in the early 70's.

Program Expansion

While continuing the work at Walagambahuwa and Katupota work began or intensified in Paranthan and Mannar in the North, Bandarawela in the up-country and Angunakolepellesa in the South. The work at Kattiyawa has shifted to evaluating the Mahaweli project as a whole. Since each project area represents significantly different physical environment or augmented physical environments (Figure 1) as well as a different social economic setting, each location has had to develop its own objectives and subsequent method of operation. This has allowed concentration on location specific problems within the overall program objectives of intensifying crop production. The agronomic and economic programs in each location is reviewed individually below.

WALAGAMBAHUWA[2/]

Site Description

Walagambahuwa is a traditional Dry Zone tank village settlement which represents around 3,000 similar settlements occupying a total of 104,200 ha (250,000 ac) of paddy tract. This region has a bimodel rainfall distribution, which is typical for most parts of the country. The two seasons are Maha, from mid September through January with an average rainfall of 930 mm (36 inches), and the Yala minor rainy season from March through May with a average rainfall of 380 mm (15 inches). In the settlement the three-fold land use pattern comprising chena (shifting cultivation) gangoda (settlement proper) and Welyaya (Paddy tract), which is characteristic of the dry zone, can be clearly seen.

Soils occur in a catenary sequence in the undulating landscape. Well-drained and imperfectly drained Reddish brown earths (Rhodustalf) occur in the convex uplands and lower mid slopes, respectively. Low humic clay soils (Tropaqualfs), the poorly drained member of the catena sequence, occur on the concave valleys and bottom lands, where most paddy tracts are found.

[2/] This section contributed by T. Senaratna and S. Mahendrarajah.

The project started in Maha 1976. Our second year work (1977/78 crop year) at Walagambahuwa was directed towards understanding better the field problems associated with early land preparation and early dry seeding of paddy in the Welyaya. Specific studies in respect to fertilizer levels, methods of land preparation, performance of varieties and water and labor use in land preparation were undertaken.

A changed in research approach was adopted to make the farmers less dependent on the project for decisions, thinking and materials. Instead the project assisted the farmers to become involved in a loan scheme with a local bank, so they could obtain sufficient funds to procure necessary materials.

The rainfall distribution as well as the magnitude differed considerable from the first season. There was 316 mm (12.6 inches) more precipitation than the first season. The most striking feature was that 45 percent of the total precipitation occured in 23 rainy days in October alone, (Figure 2, Table 1) which compares was only 8 rainy days in October 1976. These differences in the magnitude and distribution of rainfall had striking implications on the field program at Walagambahuwa. An immediate result was shifting from our earlier intentions of dry tillage to a wet tillage for the Maha rice. The extra rain also filled and spilled the tank in the 1st week of November, so that water would not be a constrain in growing two rice crops this year, for the first time in known history. This allowed the program to evaluate the maximum intensity cropping pattern available (Figure 3). The second year's field work further substantiated the close relationship between incident rainfall characteristics, cropping potential and crop management under village tank conditions.

Testing of Rice Varieties

Four short age class (three months) rice varieties were evaluated in farmers fields. The farmers choice was taken into account. Of all the farmers, 39% opted for 62-355, a semi-tall variety with droopy leaves, 43% of the farmers selected BG 34-8, a new improved variety (Dwarf erect leaves), and 18% of the farmers selected variety BG 34-6 or BG 94-1, two new improved 3½ months varieties (Table 1). There was no significant difference between 62-355, BG 34-8 and BG 34-6. However, BG 94-1 did stand out with the highest yield of 4.0 t/ha. Although this 3½ months variety gave the highest yield, further studies need to be undertaken to understand how these varieties would fit into a regular cropping pattern, and irregular rainfall.

Fertilizer Use

Farmers decision to use fertilizer appeared to be more guided by their desire to avoid risk of the high investment, than a consideration of crop needs. From trials conducted in the field, the farmers decision regarding basal fertilizer appeared to be sound. Over all varieties there is no

significant difference in the yield (Table 3) with (100 kg/ha) and without the use of basal fertilizer provided one top dressing was done with 30 kg/ha of urea. Apparently N was the only major nutrient in short supply. In the case of BG 34-8 the use of basal fertilizer appeared to give a significantly higher yields. V riety 62-355 showed no differences in yield with and without basal application. We compared some of the fertilizer practices the farmers adopted in the field during this season. The use of muriate of potash and basal fertilizer either together or independently showed no beneficial effect (Table 3). It appears that these soils which were not cultivated for about 8 years were still sufficiently rich in these nutrients so as not to show any response.

Input Use

To further substantiate lat year work, records were maintained on cost of land preparation, seeding, inputs used, and cost of harvesting and threshing. To be more realistic these records were standardized to average farm paddy holding of 0.21 ha, although actual holdings varied from 0.1 ha to 0.7 ha. The total cash expenditure for average holding size was Rs. 202.11, the total labor cost for average holding was Rs. 234.25 and the total cost of production for an average holding size was Rs. 436.34, which would be Rs. 2081/ha (Rs. 842.34/acre). Average farmer produced 637 kg of paddy. Table 4 shows cost and returns per hectare based on 46 farmers.

Testing of component packages in different land elements in the paddy field

Results obtained during the Maha 1976/77 showed there were three major land elements on subdivisions identified as follows:

Land Element A - Soils of moderate to inperfectly drained, found mostly on the side of the paddy tract.

Land Element C - Soils with variable drainage and texture which includes alluvium within the LHG, which is the largest of the land elements running down the center of the tract.

Land Element D - Heavy textured soils of poor drainage, found at the bottom of the tract where water backs up from a elevated roadway, and subsequent tank below the road.

Following on these results the land elements were used to partition the 18 packages of component technology being evaluated. Six packages are not included in the evaluation as sufficient number of replicates were not obtainable due to the heavy rainfall modifying the intended establishment technique. All packages evaluated had at least 4 replicates for each package.

The main objective for testing of package were to compare different levels of input combinations such as variety, method of planting, seed rate and fertilizer in a given land element. In farmers' field, it was felt that the management of a crop has to be oriented to the consideration of the totality of the different components than to individual levels of a single factor.

In the following tables the first column indicates the variety BG 34-8 or 62-355, the second column whether broad-cast (BC) or row seeded (RS) the 3rd column whether seeds were sown pregerminated (P) or ungerminated (U), the 4th column the seed rate in bush/ac, and the last column the use of basal fertilizer, + where used, and - when not used. The 1 or 2 indicate the number of top dressing given.

Element A	Packages tested	Mean Yield	F value
	62-355/BC/P/3/-1	3338	0.38
	62-355/BC/P/2/+2	3530	
	62-355/BC/P/3/+1	3082	

There were no differences between the packages tested in land Element A. As evident by no striking differences between the different packages tested.

Element C	Packages tested	Mean Yield	F	F Tab.
	1. BG 34-8/BC/P/2½/+2	4317	2.45	2.87
	2. BG 34-8/RS/P/2½/+2	4231		
	3. BG 34-8/BC/4/2½/+2	3727		
	4. BG 34-8/RS/P/1½/+1	4048		
	5. 62-355/RS/P/1½/+1	3166		

Package No. 1 performed the best with 4.3 tons/ha in land Element C. Variety BG 34-8 shows no difference in yield when sown either broadcast or row seeded. There was however, around 500 kg reduction in yield when seeds are sown ungerminated. Variety 62-355 gave the lowest yields and appear to be less suitable for this land Element - at least in an usually wet year.

Element D	Packages tested	Mean Yield	F value
	1. BG 34-8/BC/P/2/-2	3419	0.26
	2. BG 34-8/BC/P/2/+2	3748	
	3. 62-355/BC/P/2/-2	3379	
	4. 62-355/BC/P/2/+2	3416	

There was no significant differences in yield between two varieties in this land element unit. The use of basal fertilizer did not appear to be beneficial for either variety.

Yala Season 1978

The Yala season 1978 was the 4th season of the project's involvement with the farmers at Walagambahuwa. During this season the farmers were completely left to themselves to decide on any activity they wanted to conduct in the paddy tract, and observations carried out to understand the farmers problems in double cropping. Since the tank had spilled it was full to capacity and there was sufficient water to grow another crop of paddy, the farmers decided a second rice crop.

Land Preparation

Land was prepared under three methods during Yala season. Thirty-three farmers used buffaloes, 8 farmers used two wheel tractor and 4 farmers used mammoty to prepare land. On the average, farmers who used a tractor finished the land preparation in one day. Those who used animal or mammoty took two days to finish the operation. However, only those who used animals did the second ploughing 10 days after the 1st ploughing. While there were no statistically significant differences in yield among the three methods, use of animals gave the highest yield. For the whole tract three weeks was taken to prepare the land requiring only two issues of water from the tank. Even with only two issues there was a wasteful use of water from the tank for land preparation. This was because work was done at different times and in different parts of the tract.

Fertilizer Use

While 19 farmers apply basal fertilizer 26 farmers did not apply. There was no significant differences in the yield (Table 5). However, 300 kg more yield was obtained when fertilizer was applied. The use of basal fertilizer showed a significant response at 10 percent. This indicates a probable response to the use of basal fertilizer with continuous cropping in the future.

Problems Associated With Double Cropping

In the second rice crop it was observed that there was a very heavy infestation of weeds in all farmers fields. This was mostly sedges with some grasses also present. It is thought that the method of land preparation, where no proper turning was done, nor time allowed for decomposition, may have accentuated the problem. Farmers made no attempt

at controlling weeds. When the plants were later weakened by stem borer damage, weeds could grow even more vigorously.

During this season several entomological studies were made.[3/] Severe yellow stem borer damage upto an average of 27.7% (range 0-80.7%) was observed during 1st four weeks after planting. It was clearly seen that where farmers used early application of insecticides, the damage by stem borer was almost negligible. The egg masses of yellow stem borer were collected and raared in the laboratory. They showed parasitism upto 34.7% with two species of parasites being collected. One was identified as a species of Trichograma, and the other is yet to be determined. The use of insecticides by the farmers, high level of egg parasitism and/or possible weather factors caused the incidents of stem borer to declined sharply towards the latter part of the season. Most of the stem borer damaged plots in the well drained portion of the paddy tract recovered fairly well due to subsequent tillering. In stem borer damaged plots in the poorly drained areas, the subsequent tillering occured when the water was drainedout from the plot. The heavy rains and blowing that prevailed during the milk stage of paddy prevented the build-up of paddy bug which was seen in some of the early flowering plots in the field. However, farmers could harvest an average yield of only 2.47 t/ha (47.6 bush/ac). This was appreciable below the Maha yield averaging 3.2 t/ha, and indicates in this wet year the rainfed Maha crop provided a better rice crop than the more traditional tank irrigated post Maha rice crop. It is thought that the low yields resulted from weeds and the pest damage.

Late Crop (3rd Crop)

After the second crop of paddy, there was still enough water in the tank for a third crop. For the 3rd crop about 1/2 of the tract was planted to the farmers choice of cowpeas and shallot (Allium annum). An unsual rain shower of 100 mm in one day occurred in August and seriously damaged the cowpeas which were planted on flat beds. The shallot did not suffer from the excessive water as they were planted on raised beds. Therefore, it is necessary to evaluate the probability of such unusual occurrences as well as studies on suitable management practices which may prevent such crop damage. Although this 3rd crop was physically possible in the paddy lands, the farmers did not appear particularly interested in it and did not give optimal management, but allowed many field to be heavily infested with nutsedges. It appeared that managing the third crop conflicted with land clearing of chena and the farmers desire for leisure time to make pilgrimages to Holy Buddhist shrines. Such pilgrimages are traditionally done at this time of year.

[3/] Entomological observations were carried out by Dr. Jinasiri, Fernando, Entomologist of the Maha Illuppallama Research Station.

Tank Storage Potential

An integral part of the Walagambahuwa Cropping System is the capacity of the tank to supply water for irrigating Yala crops after the initial Maha rice and provide domestic water supply. The storage capacity and irrigation potential in a given year is directly proportional to the Maha rains (Sept. - Jan). The two years study provided to constrasting examples of this potential. The first year the Maha rains amounted to a moderate deficiency of 817 mm compared to the 930 mm average. This provided 1.96 m of water in the tank, which was essentially only enough water to assure a domestic supply and irrigate some drought hearty pulse crops. In the second year an additional 200 mm of Maha rains provide a moderate surplus with 1036 mm total and provided 3.10 m of water which exceeded the tanks capacity (Figure 4). This was enough water to irrigate the entire tract for an early maturing paddy crop, after the rainfed paddy crop, plus a third crop of pulses and still have 1.2 m of carry over. Using the 800 mm of Maha rains as minimum for irrigation, and 1000 mm as a full tank and maximum irrigation potential a frequency distribution of irrigation potential was worked out for the 30 years of rainfall records from nearby Maha Illupallama research station. This indicated that 37.5% of time the Yala irrigation potential was essentially zero, equal percentage it was sufficient for a full tract of paddy, and 25% it was somewhere in between and could have irrigated either a fraction of the tract to rice or the entire tract to an upland crop (Table 5). Thus the double cropping potential is approximately 60%, however, the double rice potential is less than 40%.

To assist the program determine the irrigation potential of the tank, the Land and Water Use Division has developed a graph and equation for determining the storage capacity of the tank as a function of the height of water, and a procedure using the derivative of the equation for determining how much water is available for irrigation vs. natural losses, and what is necessary to assure the domestic supply (Figure 5)[4/]. This evaluation for the 1976 Maha 1977 Yala showed that only 11% of the stored water was available for irrigation while some 85% went for natural losses due to evaporation, seepage and percolation which was necessary to assure the domestic supply.

Economic Studies

Economic investigation on resource use and returns was continued with a 40% sample of farmers. The primary objective of this was to highlight the consistancy or change in the pattern of resource use, especially labor, over the previous year.

4/ Studies on water balance in the tank are being carried out by S. Somasari, Head, Soil and Water Use Division.

Labor Use

The pattern of labor use over the weeks was found to be the same as in 1976/77 with two peak use on the first week of October and first week of February. These peaks are associated with the planting and harvesting operations, respectively, of the Maha crop. However, the peak utilizations were approximately 50% lower than those recorded in 1976/77. It is striking to note that the labor utilization is more evened out in 1977/78 especially during the harvesting of Maha crop (Figure 6). This could be attributed to delayed harvesting of chena crops, imposing less pressure during harvesting of the Maha rice crop.

The overall weekly labor allocation for farming activities was found to be only 36 hours/family which is 74% of that of the previous year (Table 7). The absolute hours of labor allocated to Puranawela and Chena land was also low. Thus it is evident that farmers worked less in 1977/78. This is perhaps due to more rational use in paddy and chena. Still the bigger porportion (41%) of labor was allocated to chena lands. It is striking to note that a higher proportion of labor was allocated to "Olagam" and "Akkarawela" rice lands. This could be attributed to the high rainfall which was favorable for rice cultivation in Maha 1977/78.

Regarding the source, 90% of the farm labor was provided by the family labor force. Hired labor constituted a very small proportion. Exchange labor has been widely used for harvesting of rice. In fact, around 50% of the harvesting labor in Akkarawela and Olagam was constituted by hired and exchange labor (Table 8). Man labor was predominantly used in all farming enterprises except in chena and homestead, where woman labor too was high, particularly for aftercare and harvesting operations.

Economics of the Cropping Pattern and Income

Two rice crops were raised in the Puranawela as permitted by the larger volumn of stored water. In other rice lands such as Akkarawela and Olagam, Maha season rice was cultivated according to the traditional practices. Highland crops and finger millet (Kurakkan) were grown in the chena lands during Maha followed by sesame (Gingelly) in the Yala season. The costs of returns of these crops for an average farm in presented in (Table 9). The chena crops performed poorly in the Maha season due to heavy rainfall. Thus in terms of returns the contributions of the chief chena crops such as Kurakkan, chillies and cowpea were very low.

In terms of value added, rice contributed most. When compared to 1976/77, the income from paddy lands has shown a sixfold increase in 1977/78 (Table 10). The overall farm income has increased by 60%.

KATUPOTA[5/]

Back Ground

The Cropping Systems Research activities in Katupota are concentrated in two rainfed lowland paddy tracts belonging to adjoining villages, Alankara and Moragane. These fall in the intermediate agroecological region with Red-Yellow Podsolic soils the major soil group. The paddy tracts under investigation are referred to as "Alankara paddy tract" and "Moragane paddy tract" respectively and located alongside the Katupota-Kaliyapitiya road isolated by patches of coconut lands. Characteristically coconut and rice constitutes the chief agricultural enterprises in this region. Rice yields are generally low in the order of 1.0 to 2.0 tons/ha. The low productivity is associates with various soil problems including plant nutrient deficiencies and moisture stress. Such situations are clearly exemplified by the Alankara paddy tract which is around 25 hectares in extent. While, the Moragane paddy tract is larger and exhibits lesser soil problems. However, the later is frequently affected by flash-floods as occured during the heavy rains last October. The flash flooding breached the bunds of many paddies washing out the young rice seedlings forcing farmers to replant. This was especially noticeable in the lower portion of the tract. Within each paddy tract three land elements could be identified namely the crest, the side paddies and the valley bottoms.

The populations of the Alankara and Moragane paddy tracts are homogeneous groups of approximately thirty and fifty families, respectively. Their high land annual crop cultivation is minimal. The cropping pattern of the paddy tract is confined almost exclusively to two crop rice-rice pattern. The cropping systems program envisages to raise the per hectare yields with this pattern and substitute upland crops for the second rice crop under appropriate land elements.

Agricultural Practices and Use of Crop Inputs

Dry sowing of rice (Kekulan) is widely practiced. Around 90% of the farmers at Alankara and 40% at Moragane dry sowed their Maha crop. Two or three ploughings are carried out before the onset of the rains, using buffalo power. Use of tractor for land preparation was minimal. The seed was broadcasted and covered by an additional ploughing. The land preparation activities for the Maha season commenced in late August and went on till mid September, while in the Yala season it was carried out during mid March to early April. Almost ninety-five percent of the area was sown with new improved, high yielding varieties such as BG 90-2, BG 94-1, 62-355 and H 4. However, the use of fertilizer was low especially

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5/ This section contributed by S. Mahendrarajah and D. Senadhira.

at Alankara. None of the farmers in Alankara used basal fertilizer at Alankara either in the Maha season or Yala season. While, 20% of the farmers at Moragane applied basal fertilizer (150 kg/ha) for the Maha season. However, almost all the farmers at Moragane and 60% at Alankara top dressed with urea although at a lower rate (40 kg/ha) than recommended. Hardly any weed control measures were undertaken particularly at Alankara, The level of input used in the Yala season was still lower. The pest problems were not critical. The lower Yala input levels could be attributed to usual poor crops, and the uncertainty induced by erratic rainfall.

Agronomic Studies

In the Maha season observation studies were undertaken with special reference to farmers management packages for rice crop and the performance of high yielding varieties. Various new high yielding varieties were introduced to the farmers fields taking into account the farmers options, while at the same time observing their performance. The higher yielding potential of Bg 34-8, BG 94-1 and BG 90-2 was evident even in low management in that they yielded 50-150% higher than the other varieties (Table 11). However, the overall yields were low. For the Maha season the overall yield at Alankara and Moragane tracts were 0.8 and 1.7 t/ha respectively, with the Yala yields similar at 0.8 and 1.5 t/ha for the respective tracts. Generally, the low yields are thought to reflect the inherent poor land quality for which high input levels could not be justified. Further, at Alankara poor crops were mostly associated with poor and uneven growth. Within the tract the upper area gave the lowest yields and the valley bottom the highest, as expected.

In the Yala season, four component technology experiments were carried out in both tracts.

a) The effect of application of basal fertilizer (3-31-14) at sowing and two weeks after sowing on the growth and yield of rice (BG 34-8).

Such an experiment was considered important in view of the widespread practice of delayed application of basal fertilizer. With the application at sowing, the plants were significantly taller at 3 weeks. gave higher tiller counts (Table 12) and flowered two weeks ahead. However, no significant difference in yield was observed. However, no significant difference in yield was observed.

b) An observation trial on the effect of heavy P mixed fertilizer (3-31-14) on the growth of early maturing rice (BG 34-8).

In the plots treated with the fertilizer (375 kg/ha) the growth and tiller counts were significantly greater than the untreated ones. In the latter, the growth was uneven and flowering was delayed by two weeks. Also the treated plots showed a five-fold increase in yield. Clearly, the mixed fertilizer application could contribute substantially to raise yield levels.

c) An evaluation of weed competing ability of four early maturing rice varieties with different growth habits.

No significant difference was found in weed count and weed weight at 3 weeks. At 2 weeks the weed count was less than at 3 weeks in all varieties. The weed weight was significantly lower in the tall variety, 62-355. Yet, the higher yield potential of improved BG 33-2 a leafy dwarf variety was evident (Table 13).

d) A spacing trial for cowpea (MI 35) in the upper area of the Alankara paddy tract.

With a spacing of 45 c.m. between rows a significantly higher yield of 1145 kg/ha was obtained (Table 14).

Economic Studies

The objective of the economic investigation was first to monitor and describe the resource use pattern. For continuous monitoring of resource use and returns, a random sample of ten farmers from Alankara and seven from Moragane were included. The resources characteristics detailed below draws heavily from the work of 1977 as well as 1978.

Resource Endowments

Land

The farm land components are the same in both villages and composed of paddy lands and coconut lands with a number of parcels in their own and adjacent villages. The average farm size at Alankara (2.6 hectares) is higher than at Moragane (1.9 hectares). Forty to sixty percent of the farm consists of paddy lands. The average paddy holding size at Alankara is 0.89 ha while that of Moragane is 0.63 (Table 15). The proportion of paddy land under the crest, slope and valley bottom are 13%, 43% and 46% respectively in the Alankara tract, while in the Moragane tract, 94% is found inthe slope and tha balance in the valley bottom. The drop from the crest to the valley bottom is around 2 meters.

Labor

Family members constitute the chief labor force and the average family size of Alankara and Moragane are 5.7 and 6.0 respectively. The adults availability for farming activities at Alankara was found to be 3.3 while at Moragane it was 3.0. A gross under utilization of labor is evident as the average weekly labor use on farming was only 46 hours

and 26 hours at Alankara and Moragane, respectively. However, the labor use is seasonal and approximately twice as much labor is utilized during planting and harvesting of rice (Figure 6 and 7). In both villages equal amount of hired labor has been employed in farming. Of the family labour allocation around 50% was contributed by men. The proportion of labour allocated to the different farm components are the same in both villages (75% farming allocation goes to paddy lands). On a per hectare basis 200 hours more labor per year was allocated to Moragane paddy tract than Alankara. However, it is a striking feature that in terms of number of hours each person at Alankara appears to work twice as hard as his counterpart at Moragane. Because of the higher per acre productivity in Moragane, this is not significantly reflected in the family welfare except that the housing at Alankara is slightly better than Moragane. The labor allocation to off-farm work (mostly in fibre mills) too is higher at Alankara (21 hours/week) than at Moragane (5.3 hours/week).

The Economics of the Rice-Rice Pattern

The mean monthly income of Alankara was Rs. 474 while that of Moragane village was only Rs. 335 (Table 16). However, in absolute terms the total income derived from the various paddy lands is almost equal in both villages. When the paddy tracts under investigation are considered alone, Moragane farmers receive approximately 50% more cash than those of Alankara. Off-farm income constitutes an important source of income at Alankara accounting for 30% of the household income.

In the rice-rice pattern, the overall labor use per hectare is the same in both paddy tracts, but 25% more cash was used at Moragane than at Alankara (Table 17). This difference in cash commitment is thought to be attributable to differences in inherent productivity between the two tracts.

Future Perspective

It is envisaged to attempt to stabilize the present rice-rice pattern in the suitable land elements and raise productivity through the use of better varieties and appropriate component technologies. A systematic evaluation of available varieties is also felt important to provide the necessary feed back to the plant breeder. Defining the suitability of the component technology, especially the fertilizer practices is of equal importance. With the identification of the different production complexes or land elements within the paddy tract, it is felt that alternative upland crops could be introduced for the Yala season in the crest of the landscape. It is intended to test and evaluated hand-in-hand patterns based on promising available varieties and relative component technology.

MAHAWELI[6/]

Background

The Mahaweli Development project is the largest development program undertaken by the Sri Lanka government. It involves the development of the entire Mahaweli Ganga (River) catchment including diverting 56.6 m^3/sec of water from the wet zone in Kandy through to sets of 8 km tunnels to the northern dry zone, and developing 400,000 ha of irrigated lands. The diversion was completed in 1976 and now the government is placing highest priority on completing the development of the irrigated lands. In response to this national priority the Cropping Systems Program initiated studies on fully irrigated areas. This was done from the base at Maha Illuppallama which happened to be located within the commend area of the Mahaweli Scheme.

The Cropping Systems work for the Mahaweli Diversion and Agricultural Development Project was initiated in the Kattiyawa Settlement Scheme. Kattiyawa represents the old existing settlement incorporated into the fully irrigated Mahaweli Project. The settlement is situated about six miles NW of the Regional Agricultural Research center at Maha Illuppallama. The area was originally settled in the late 1940's with a 5 acre paddy and 3 acre upland allotments. The area falls within the same agro-ecological region, as Walagambahuwa with similar land form and soil types.

However, these lands are located at a lower level in the overall topography and have a higher proportion of imperfectly and poorly drained soils in the catena. In addition these lands have a year-round irrigation facilities, from which two 4 month water issues are made for Maha and Yala season, respectively. The second water issue is a result of the Mahaweli diversion scheme and has been available only since 1976.

After observing the farming operations it appeared that the problems were more associated with individual rice crops rather than with cropping patterns and their major problem areas could be defined as:

1. Labor shortage in crop establishment
2. Power shortage in tillage
3. Problems associated with threshing, on-farm storage and marketing.

[6/] This section contributed by R. Seneviratne, M. Silva and J. Wahab.

Agronomy Studies

Problem in Relation to Crop Establishment

In 1977/78 Maha season problems related to crop establishment were studied.

It appeared that in early 1960's broadcasting had been replaced by transplanting which increased the labor requirement in crop establishment by 40 times. As labor availability and maintenance have recently become severe constrains, two less labor consuming methods, namely broadcasting and row sowing, were tested on the three soil types with different methods of weed control, in order to identify their ability to compete with transplanting.

The yields of crops thus established were correlated to weed growth while weed growth seemed to be dependent on:

a) the water regime of the soil at the period of crop establishment

b) position of the soil in the landscape

It was observed that the weed growth on the poorly drained soils which are located in the lowest portion of the catena was much higher than on the well drained and imperfectly drained soils (Figure 9).

It was interesting to note that the grassy weeds were dominant on the well drained and imperfectly drained soils while sedges were dominant on the poorly drained soils.

The yield of rice as affected by the condition discussed above is illustrated in (Figure 10 and Table 18).

Problem of Power in Relation to Tillage

Normally a farmer starts his land preparation almost two months after the harvest of the previous crop. During this time the field can get heavily infested with weeds (Figure 11).

New Tillage Pattern

In contrast, the new tillage pattern was started just 4 days after the harvest of the previous crop, in a moist weed free condition. Under these conditions a tractor with a tine tiller was able to dry plough the land and when water was issued the land preparation completed with a buffalo drawn leveller (Figure 10). It was observed that the new tillage

practice could control weeds five times more effectively than existing method (Figure 11). Thus the normal traditional land preparation operation including wet ploughing, puddling and levelling of a weedy field has made simple with the advantages of:

a) minimum waterused in land preparation

b) the operation started very early in the season and could be completed in a much shorter time, allowing:

   1. reduction in water loss
   2. late farmer to get their land prepared in time
   3. post seasonal water issues eliminated

c) less weed problems to facilitate using easy ways of crop establishment such as broadcasting are possible.

These studies involving crop establishment and tillage are focused on two major constrains in rice product in fully irrigated parts of Dry Zone lowlands of Sri Lanka. Alternative methods are suggested which require less labor power. Weed-growth - landscape-moisture regime, were studied as related factors in crop establishment. A new tillage pattern was evaluated as a means of facilitating easy crop establishment techniques.

Monitoring

In addition to agronomy studies monitoring activities were conducting involving 27 farmers and 10 two wheel tractor owners. This consisted largely of observing the farmer activities as it effect his timely operations during an initial turn around periods and how the two wheel tractors contributed to the farmers' activities.

The results indicated that the farmers were taking better than two months after water issue to complete their crop establishment activities. This contrasted with the Irrigation Department projection of one month for crop establishment and issuing water accordingly. In taking two months, however, the farmer remained busy on rice related activities for the entire period. It appeared that the farmer spent a disproportionate amount of time reparing his bunds, but may have really been doing this, while waiting for tractors to become available. There was considerable variability between farmers, with the farmer owning tractor getting their land prepared ahead of those without, and additional variability when the farmer were blocked according to proximity to the Kattiyawa tank bund. The farmer away from the tank lagged behind those near the tank. The farmers also utilized a considerable amount of hired labor during the Maha season for transplanting. Much of this labor came from a migratory work force the farmers invited into the area from their previous villages. Once invited the farmer had to provide room and meals for the laborers over and above

their wages. During the Yala crop the migratory labor were not employed and most of the rice was broadcast instead of transplanted.

The study of the two wheel tractors showed they were not being used a effectively as projected. It was anticipated that two wheel tractors would be available to prepare 10.12 ha (25 Ac) in a month, but the study showed the two wheel tractor preparing only 6.08 ha (15 Ac) in two months i.e. only one third the project rate. The reasons for this was that many lands were actually tilled two or three times at 10 to 14 day intervals instead of once; frequently the owner preferred to use the tractor for short distance hauling including "Jeepney" service instead of putting them in the paddy tract which abused the machine, and some were reluctant to rent out their tractor in case of breakdown and not being able to get spares in time for reparing the tractor prior to needing it for land preparation of the subsequent crop. It was felt that finding a means of facilitating communication between farmers needing land preparation and tractor owners might assist in reducing turnaround periods.

The experiences in Kattiyawa quitely provided considerable insight into the problems of fully irrigated areas and provides a strong base for an expanded involvement that will provide appropriate information needed to assist the entire Mahaweli development effort.

PARANTHAN[7/]

Paranthan is located in the northern end of the island just prior to passing onto the Jaffna Peninsula. The climate there is among the harshest found in the country. While the Maha rains average near 1300 mm and are comparable to most of the country, the Yala rains are greatly diminished. This puts a severe constrain on cropping potential during the Yala period. Dispite this the cropping systems activities are focused on the rain fed bunded paddy lands locally referred to as Manawari lands. Most of the Manawari lands in the Paranthan area have sandy surface soils that is easily worked in a dry condition. This allows a considerable portion of the area to be prepared by 4-wheel tractor with tine tiller prior to the rainy season. Some of the area does have salinity problem steming from the low elevation and proximity to Jaffn Lagoon. The present land use consists largely of one, preferrable, dry seeded paddy crop during the Maha season and extensive pasturing of goats and cattle on the stabble during the Yala. The grazing can seriously interfear with annual cropping during Yala unless fencing is provided. Present cultivation during the Yala is almost exclusively restricted to intensive patches surrounding a well or along side creeks flowing with drainage water from the command area of the Iranamadu tank just south of the area. One farmer

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[7/] This section contributed by A. Senthinathan and S. Sritharan.

was observed to grow a successful rainfed crop of groundnuts in one fenced in field. Much of the area appears to have some severe social-economic constrains in the form of "remote centrol" owners. This is many of the holdings are relative large size, 7-15 ha, for which the owner has other commercial activities and hires a manager to actively work the land for a salary.

The Cropping Systems efforts started in October 1977 by selecting the villages of Kandawela in the main Mannawari area and Thatuwanketti in the saline areas. The initial years activity was largely one of observation and problem identification. It is currently expanding to begin actively conducting agronomy trials.

The two objectives of these agronomy trials are:

1. to investigate the possibility of increasing the cropping intensity of Manawari lands by including a second crop after rice

2. to investigate the possibility of increasing the yield of paddy by providing a set of appropriate component technology for Manawari rice cultivation.

The initial field effort will concentrate heavily on component technology with variety evaluation, weed control, fertility etc, all using a dry seeded rice base (Table 19). This will be followed by a series of upland crops in the Meda using residual soil moisture and then repeated during the Yala rains. This will provide two contrasting moisture sources for post paddy cropping. In addition to the agronomy work economic monitoring is commencing with several farmer in the area. This monitoring will concentrate on labor availability and power for land preparation and threshing.

MANNAR[8/]

The cropping systems effort in Mannar is a minor program evaluating an isolated but important rice production area. It is operated by a single agronomy research officer attached to the Mannar District Agricultural Extension Officer Office. Mannar is located on a deltic plain along the North Western coast of the island, just across Adam's bridge from India. This is again one of the dryer parts of the island with a rainfall distribution similar to Paranthan. However, the rainfall is supplemented by a large unique network of very shallow interconnected tanks the total surface

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[8/] This section contributed by S. Thirianathan.

of which covers nearly 50% of the major paddy producing areas. Water for the tanks is continously supplied from the Giant tank, an extremely large but shallow tank on the eastern edge of the area. Surrounding the tank based paddy areas are smaller areas using tube well irrigation that must be carefully watched for salinity intrusion, other tracts with saline soil problems and some paddy tracts on vartisol.

The general cropping systems in the area is for a unique combination of Maha rice below the tanks, followed by Yala rice within the tank beds, two rice crops under the tube-wells and a single rice crop in the saline and vertisol areas. The work is concentrated on agronomy trials aimed in investigating the potential for deep water rice in the tanks (tank rice) during the Maha and upland crops below the tank during Yala in the tank areas; means of growing upland crops in Yala with tube well irrigation to avoid well salinity in the tube well area; and evaluate tolerant rice varieties for the saline and vertisol area. In addition, well-salinity monitoring program is being undertaken to follow water table drawdown and the salinity instrusion proglems as the number of tube wells and water pumps in the area expand. No economic analysis is anticipated for the area.

BANDARAWELA[9/]

Bandarawela is located in the south eastern portion of Sri Lanka's up-country mountains at an elevation centering around 1300 m. The terrain is thus rolling or mountainous in which rice is grown on terraced mountain sides or occasional broad valley with tea or vegetable in the surrounding high lands. As in most mountainous areas, the mountains forms a physical barrier for prevailing climation circulation causing rapid changes in climatic condition over relatively short distance. This is most noticeable in terms of rainfall distribution and local wind funneling during certain period of the year reaches intensities restrictive for tall crops and can cause sterility or shattering in rice if it occurs at flowering or maturity. In Bandarawela this blowing can become a severe problem at the beginning of the South West monsoons during the month of May, June and July and can restrict crop selection and cultural activities. The rainfall in the area is generally classified as intermediated with a distinct bimodal pattern common to most of the island. The Maha rains are similar to those of the dry zone while the Yala rains are significantly greater. However, the direct beneficial efforts of the rains on crop activity may be considerable negated by essentially all paddy tracts having a local irrigation system developed by diverting streams shortly above the tract or controlling the water along the slopes. This usually provides sufficient water for moisture requirements of most crops and allow many operations to proceed independent

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[9/] The section contributed by J. Wahab and N. Weralugolla.

of incident rainfall. The beneficial effects of rainfall is largely as the source for keeping the underground water supply charged. The rainfall continues to have the direct adverse effect of excess water on sensitive crops which must be designed around. Of greater concern in the physical environment is the relatively cool temperature induced by the high elevation. Although the annual variation in daily minimum temperature is not great, does fluctuate around the critical temperature for several crops, including rice. This, then becomes a more important determinant of crop establishment than rainfall.

The cropping systems in the paddy tracts throughout most of the areas is a fairly intensive cultivation of rice, starting in January after the Maha rains, followed by one or two vegetable crops, a large portion of which is potatoes, but also includes cabbage, bush beans and pole beans. The potatoes frequently have to be harvested early to avoid damage during the heavy Maha rains. In addition to paddy fields, many farms have upland "hena" parcels used extensively for rainfed vegetables. Virtually all field operations are done by hand with very limited amounts of animal or tractor power.

Cropping systems studies began in the Bandarawela in April 1978 after a multi-disciplinary group visited the area to select a study site. The group included cropping systems agronomist, economist and land use personnel. After visiting the area the village of Uva Paranagama was selected and an Agronomy Research Officer from the Research Division along with an Economic Assistant from the Agricultural Economic Division were assigned to the area fo. study. Agronomy acitivity commenced with the current vegetable crop looking at different varieties of potato, bush beans and pole beans. In addition component technology in chemical and cultural control of disease is being tried on various vegetables. Actual cropping pattern studies are expected to begin in January with the rice crop. This will be a time when virtually all farmers will be together in their farm activities. At that time one main objective of the studies will be to shorten the duration of the rice crop to allow the following potato crop alonger season for root filling before Maha rains set in. Finally after a visit to the area showed considerable staggering in activity between different paddy tracts, a study will be conducted to evaluate the micro-climatic variability between different tracts. This will largely entail determining timing and severity of incessent winds between seven distinct tracts surrounding the main tract.

Economic studies are expected to start immediately, October 1, with the monitoring of 22 farmers. This is scheduled to be expanded in December to 50 farmers. These studies will mainly concentrate on labor which will be partitioned according to family, hired and exchanged and on farm inputs.

ANGUNUKOLAPELLESSA[10/]

The cropping systems work in Angunakolapellesa is just now getting started and has not had time to develop a program. Angunukolapelessa is located in the Uda Walawe irrigation scheme of the Southern Dry Zone. The government is hoping that area will become a major cotton producing zone, and is developing cropping systems based on rice-cotton on higher areas and rice-rice on lower areas. Soil problems in the area include serious salinity in the lower third of the irrigation scheme. This has resulted in several settlers with paddy farms, abandoning their farms, and returning to their original homes. The cropping systems program presently has one agronomy research officer detailed there and hopes to get an economic assistant available within the coming year. It is hoped that cropping systems work will eventually be spread over the three major division of the irrigation scheme.

[10/] This section contributed by M. Silva.

APPENDIX A

PROPOSED RESEARCH PROGRAM - ECONOMIC ASPECTS UNDER CROPPING SYSTEMS PROJECT[11/]

The economic component of the cropping systems program will be organized in such a manner that there would be certain uniformity in the collection of data from all the sites that will be involved in the project.

I would like at the out-set to state very briefly a hypothesis which in my opinion exists in the peasant sector of this country. Namely, the 3 unit farm concept. By this I mean that each farm consists of 3 identifiable components, namely the home garden, the highland and the lowland. There may be variations in the actual structure of these 3 units under different conditions. For example under the minor tanks scheme there could be the Akkarawella in addition to the Puranawela, both of which fall into the lowland (paddy land) category. In some instances, the highland may be irrigable highland or unirrigable highland, such as the chena. Furthermore, the home garden may be an entity by itself or would sometimes be part of either the highland or lowland and also carry a certain amount of livestock. The monitoring programs that would be involved under the cropping systems project would essentially involve the collection of data from each of these three identifiable components.

Methodology

The methodology adopted in the economic studies would essentially be a base-line survey followed by the maintenance of record books on farms. The base-line survey would essentially be done in order to ascertain the following basic information:

a) average land holding in the site area

b) the average family component among farmers on the site

c) labor availability on the site

d) the extent and use of family labor, hired labor or exchange labor among farmers

e) the crops grown in the site and the average extent under each crop grown by each farmer

f) the average yields obtained by the farmers for the individual crops in the site

g) estimate of cost and returns and consequently the average family income among farmers in the site.

11/ Contributed by N. Ranaweera

With this basic background, it would be possible to get a rough approximation of the present performance of the farmers and also to some extent ascertain the productivity of the land. It will not however provide any information on the constraints that may exist in trying to intensify cropping which is the main objective of the cropping systems program.

From the results of the base-line survey, it is possible for us to select what are considered "average" farmers on whose field record books will be maintained. In the first year of operation, (excluding the sites at Walagambahuwa and Katupota), it is proposed to monitor the activities of the farmers in relation to their current cropping patterns, with a view to obtaining the information necessary to estimate their resource components and their levels in each site. For example, we hope that an estimate of the labor availability and time spent can be obtained on a weekly, monthly and seasonal basis. This labor profile will provide us with information as to whether any intensification of the cropping pattern can be handled or whether there would be definite constraints in increasing their present cropping intensity.

The maintenance of farm record books on farmers fields will be done in each of the 3 identifiable components stated earlier. Namely, the home garden, highland and lowland. Records will be maintained separately in each of these components. In this manner it is possible to analyze the time actually spent by the farmer and his family or by the use of hired labor or exchange labor on each of these independent components of the farm. Provision will also be made to record any activities that are done by the farmers if any livestock is present. These records will be summarized weekly, for each farmer and for the site as a whole. This weekly summary will then be tabulated and profiles for each of the individual items (labor use, capital use, land use) involved in the production process.

The summary will be obtained in the following categories:

i. Resource used for each crop in the operation

ii. The resources used for each component of the farm

iii. Profile of resources used for a particular cultivation season.

After one year's monitoring of this process, it is possible to then work with the agronomic component in trying to determine how the cropping intensity can be changed.

This would be one aspect of the monitoring exercise. In collaboration with agronomic component at each site, the experiments that are conducted by the Agronomist will also be monitored primarily in relation to labor use, capital use and also the net profitability of changing the cropping pattern. Any changes in the cropping calendar will be closely monitored in relation to labor demands and will be compared with the labor supply situation that would be obtained from the monitoring of

farmers in relation to their present cropping pattern. This would enable the Agronomist and Economist to compare and see to what extent there can be a conflict in labor demand situation or whether there is a possibility of integrating the unused labor and land and intensifying the cropping pattern of the farmers.

Socio Economic Factors

Since any agricultural program on a site would also include the availability of the main resource such as, labor capital as well as other facilities, such as marketing, availability of inputs etc, the whole site area will be surveyed and information obtained as to the constraints facing the farmer. This would enable the researcher to get an estimate of the actual constraints that are hindering increasing their present production levels. Furthermore, once identified, if there are any institutional factors that did constain the present production program, such a constraint will have to be rectified if an effective program is to be launched in the future. This would mean that the researcher would have to obtain the cooperation of the respective officials and their institutions in order to see that such constraints are removed.

After a period of two years or later when the new cropping pattern has been in operation for a time which may be considered reasonable an evaluatory study will have to conducted. The results obtained in such a study will be compared with results of the base-line survey done prior to the inception of the program. The results so obtained could provide an estimate as to whether the farmers have really benefitted from the new intensified cropping pattern that has been introduced on to the site after taking into consideration the possible risks involved in intensifying the cropping pattern particularly in relation to the availability of inputs and their institutional facilities that are needed by the farmers.

APPENDIX B

GLOSSARY

Chena/Hena:	The land cleared for shifting cultivation on an 8-10 year cycle. Presently the cycle has become much shorter and the cultivation more permanent.
Puranawela:	The ancestral rice land found immediately below the tank bund.
Akkarawela:	The recently acquired rice land at a slightly higher elevation, bordering the Puranawela and usually dependent on the tank for cultivation.
Olagam:	The rice lands belonging to the villages found in other villages under similar tanks.
Manawari land:	Bunded rainfed rice lands found in the dry zone generally referring to extreme northern areas.
Kekulan:	The local term for dry sowing rice.
Maha season:	The major cultivation season which commences in Mid-September with the onset of the North East Monsoonal rains and extends upto mid March.
Yala season:	The second cultivation season which extends from March to September during which the minor South West monsoonal rains are exprienced.
Meda Season:	The period between Maha and Yala which is occasionally used for short age crop.

Table 1. Weekly rainfall distribution in mm. and number of rainy days. Walagambahuwa 1977/78.

		Week	Rainfall in mm.	Number of rainy days
1977				
	September	2 - 8	0	
		9 - 15	0	
		6 - 22	0	
		23 - 29	85	3
	October	30 - 6	65	5
		7 - 13	56	3
		14 - 20	214	6
		21 - 27	161	5
		28 - 3	11	2
	November	4 - 10	48	3
		11 - 17	207	3
		18 - 24	32	1
		25 - 1	18	3
	December	2 - 8	13	2
		9 - 15	0	
		16 - 22	64	2
		23 - 29	0	
1978				
	January	30 - 5	41	2
		6 - 12	0	
		13 - 19	0	
		20 - 26	4	
		27 - 2	0	2
	February	3 - 9	0	
		10 - 16	0	
		17 - 23	92	2
		24 - 2	25	1
	March	3 - 9	0	
		10 - 16	0	
		17 - 23	0	
		24 - 30	40	1
	April	31 - 6	0	
		7 - 13	13	1
		14 - 20	0	
		21 - 27	22	1
	May	28 - 4		
		5 - 11		
		12 - 18		
		19 - 25		
		26 - 1		

Table 1. (Cont'd.)

	Week	Rainfall in mm.	Number of rainy days
June	2 - 8		
	9 - 15		
	16 - 22		
	23 - 29		
July	30 - 6		
	7 - 13		
	14 - 20	85	
	21 - 27		
	28 - 3		
August	4 - 10		
	11 - 17		
	18 - 24		
	25 - 31		
	Total	1,296 mm.	48 days

Table 2. Performance of paddy varieties tested in the paddy land, Walagambahuwa - Maha, 1977/78.

Varieties	N*	Mean Yield kg/ha	Mean Yield (bu/ac)	Std. Dev. (kg/ha)	CV	To test comparison
62 - 365	18	2933	(56.5)	935	28	N.S. between 62-355/64-8
BG 34 - 8	20	3119	(60.1)	656	21	Cal. t = 0.67
BG 94 - 1	3	4049	(78.0)	1110	17	
BG 34 - 6	3	3123	(60.2)	557	17	

* N for all treatments indicate the number of parcels, each treatment was tested in the paddy tract.

Table 3. Comparison of various fertilizer treaments in three experiments in paddy land of Walagambahuwa during Maha 1977/78.

Treatment	N	Mean Yield kg/ha	Mean Yield (bu/ac)	Std. Dev. kg/ha	CV	
			Experiment 1			
With basal (3-31-14) + top dressing	21	3067	(59.1)	845	27	N.S. difference
Without top dressing without basal	13	2853	(55.0)	422	15	
			Experiment 2			
62-355 with basal	10	2868	(55.3)	899	31	Cal. t - 1.03 N.S.
Without basal	5	2682	(51.7)	351	13	
34-8 with basal	11	3247	(62.6)	790	24	Cal. t - 3.14
Without basal	8	2961	(52.0)	458	15	Significant + 05
			Experiment 3			
Only basal (3-31-14)	6	2719	(52.4)	648	23	
Only muriate of potash	7	2959	(52.0)	353	11	
With basal (3-31-14) and muriate of potash	18	3113	(60.0)	729	23	
Null treatment	5	2966	(57.1)	601	20	

Table 4. Total cost of production and returns from an hectare of paddy in the Welyaya - Walagambahuwa.

Cash inputs Rs.	Labor* Rs.	Total cost Rs.	Yield kg/ha	Gross return	Net return	Return Cash Cost
964.11	1117.43	2080.58	3038.63	5784.61	3711.49	4828.56

*Based on Rs. 8-00/day for men, Rs. 6/day for women and Rs. 5/day for childeren.

Table 5. Comparison between the use of basal fertilizer and no basal fertilizer in farmers plots. Walagambahuwa paddy tract Yala 1978.

	N	Mean Yield (kg/ha)	Std. Dev.	CV	T. test comparison
No basal	36	2260.45	625.45	27.65	Cal. t = 1.8095
					tab. t = 2.17 ns.
With basal	19	2586.88	557.27	21.62	

Table 6. Projected effect of Maha rains on tank storage and Yala irrigation potential for the Walagambahuwa Tank.

Year	Maha rains mm	Water level(m)	Water storage(m^3)	Irrigation potential
1976-77	817	1.86	78,720	Minimal
1977-78	1036	3.18 (spill)	320,000	Full
30 year average	937			

Frequency occurance of Maha rains for 32 years (mm)

<600	600-800	800-1000	1000-1200	>1200
7	5	8	6	6

Frequency of no irrigation	<800 mm	=	12/32	=	37.5%
Frequency of full irrigation	>1000 mm	=	12/32	=	37.5%
Frequency of partial irrigation	800-1000 mm	=	8/32	=	25%

Table 7. Mean weekly labor allocation (hours)per family.

Component	Hours		Percentage	
	1976/77	1977/78	1976/77	1977/78
Puranawela paddy	11	5	15	11
Akkarawela paddy	0	2	0	5
Olagam paddy	3	9	4	20
Chena	38	18	51	41
Homestead	11	2	15	5
Off farm work	12	8	16	18
Total	75	44	100	100

Table 8. The sources of labor in various farm operation, Walagambahuwa

Operation	Source of labor	Puranawela	Akkarawela	Olagam	Chena	Homestead
Land preparation	Family	88	84	78	89	100
	Hired	11	1	12	8	-
	Exchange	1	15	10	3	-
Weeding and after care	Family	94	95	100	99	100
	Hired	6	-	-	1	-
	Exchange	-	5	-	-	-
Harvesting	Family	71	51	55	88	100
	Hired	6	17	26	7	-
	Exchange	22	32	19	5	-

Table 9. The costs and returns of cropping of the average farm 1977/78.

Crop	Extent (hectare)	Gross return Rs.	Cash cost Rs.	Total cost Rs.	Return over cash cost Rs.	Net return Rs.	Return per Rupee	Return per labor hour
Paranawela								
Maha - rice	0.2	1019	178	489	841	530	4.72	2.94
Yala - rice	0.2	839	232	495	607	344	2.49	3.45
Akkarawela - rice	0.1	470	93	185	377	285	3.79	3.83
Olagam - rice	0.44	2078	462	855	1616	1223	3.85	4.95
Chena - Maha:								
Kurakkan	0.308	111	5	330	106	-219	21.50	0.36
Rice	0.055	133	32	97	101	36	3.45	1.80
Chillies	0.083	109	79	191	30	-82	0.54	0.24
Cowpea	0.069	103	17	137	86	-34	4.63	0.59
Soybean	0.016	27	9	32	18	- 5	4.25	1.66
Green Gram	0.013	32	5	29	27	3	6.78	1.38
Black gram	0.018	63	4	39	59	24	14.55	1.47
Mixed Crop	0.344	557	101	353	456	204	4.28	1.98
Chena - Yala:								
Gingelly	0.297	496	53	207	443	289	8.36	4.91

Table 10. Income from paddy and chena lands in 1976/77 and 1977/78 Walagambahuwa.

Component		Rupees per month (Return over cash costs) 1976/77	1977/78
Chena:	Maha	95 (36)	74 (17)
	Yala	40 (15)	37 (9)
Rice Lands:	Maha	35 (13)	236 (55)
	Yala	11 (4)	51 (12)
Off farm		86 (32)	38 (7)
	Total	267	430

Note: Figures in parenthesis refer to percentage of total.

Table 11. The average yields of paddy varieties in the two paddy tracts at Katupota.

	Maha Season 1976/77		Yala Season 1977	
	Alankara	Moragane	Alankara	Moragane
BG 90 - 2	1.00	2.25	N.R.	N.R.
BG 94 - 1	N.R.	2.47	1.12	1.67
62 - 355	1.19	1.77	0.84	1.57
BG 34 - 8	0.67	1.84	1.13	N.R.
BG 11 - 11	0.57	0.74	0.27	N.R.
H4	0.69	1.39	N.R.	N.R.
Wanni heenati	0.71	0.49	N.R.	N.R.
Pachchaiperumal	N.R.	0.52	N.R.	0.91
All Varieties	0.78	1.68	0.84	1.49

Table 12. Tiller count at 3 weeks of early maturing BG 34-8 rice variety treated with and without basal fertilizer (3-31-14) Alankara and Moragane - Yala 1978.

Treatments	Farmers Field 1	2	3	4	Mean
			Alankara		
1) At sowing 125 kg/ha	3.2	3.4	3.0	3.5	3.28[b]
2) At sowing 250 kg/ha	6.6	7.4	4.3	7.8	6.53[a]
3) 2 weeks 125 kg/ha	2.6	2.0	1.9	2.1	2.15[c]
4) 2 weeks 250 kg/ha	3.6	4.7	4.0	3.7	4.00[b]
	C.V. = 20%		LSD .05 = 1.27		
			Moragane		
1) At sowing 125 kg/ha	3.4	4.8	3.1	3.2	3.44[a]
2) At sowing 250 kg/ha	2.5	2.4	2.7	2.4	2.51[b]
3) At 2 weeks 125 kg/ha	2.0	2.1	2.2	2.0	2.10[b]
4) At 2 weeks 250 kg/ha	3.0	3.5	3.0	3.7	3.30[a]
	C.V. = 10.7%		LSD .05 = 0.48		

Table 13. Yield performance (kg/ha) of early maturing rice varieties without weed control, Moragane and Alankara Yala 1978.

Variety	Farmers Field 1	2	3	Mean	
		Moragane			
BG 34 - 8 (dwarfy)	2193	2219	2441	2284	F Value 3.51 ns
62 - 355 (traditional medium tall)	2732	2709	2856	2766	
BG 33 - 2 (dwarf leafy)	3004	2391	3088	2828	
BG 77 - 3210 (improved tall)	1851	2079	2672	2201	
		C.V. = 11.6%			
		Alankara			
BG 34 - 8	3330	3514	2631	3169	
62 - 355	3882	3459	2355	3232	
BG 33 - 2	3754	3073	2834	3220	
BG 77 - 3210	3422	2263	1803	2496	
		C.V. = 21.3%			

Table 14. The yield (kg/ha) of 75-day cowpea variety MI-35 at different spacing, in the upper area, Alankara paddy tract, Yala 1978.

Spacing between rows	Farmers Field 1	2	3	Mean
35 c.m.	1033	824	502	786.3[a]
45 c.m.	1318	1345	774	1145.7[b]
60 c.m.	736	892	619	749.0[a]
C.V. = 15.7%		LSD .05 = 318.9 kg		

Table 15. Average size and parcelization of farm holdings of the villages; Alankara and Moragane.

Components of farm	Average size (ha)		Ave. no. of parcels	
	Alankara	Moragane	Alankara	Moragane
Paddy tract (yaya)	0.89 (34.4)	0.63 (33.7)	2.5	2.7
Other paddy	0.58 (22.4)	0.14 (7.5)	2.1	0.9
Coconut lands	1.05 (40.5)	0.95 (50.8)	2.4	3.3
Other highlands	0.07 (2.7)	0.15 (8.0)	0.3	0.3
All	2.59 (100.0)	1.87 (100.0)	7.3	7.2

Note: Figures in parenthesis refer to percentage of total farm.

Table 17. Mean labor and cash use and returns in a hectare rice-rice cropping pattern in Alankara and Moragane paddy tracts.

	Maha - Rice		Yala - Rice		Rice-Rice Pattern	
	Alankara	Moragane	Alankara	Moragane	Alankara	Moragane
Labor - man days	70	104	116	51	94	92
Cash costs (Rs.)	509	784	668	735	611	763
Gross returns (Rs.)	1186	2402	1522	2210	1350	2318
Return over cash costs	678	1606	791	1657	732	1554
Return over all variable costs (net return)	143	847	-105	928	22	900
Return per rupee cash investment	1.92	2.69	1.18	2.67	2.35	3.58
Return per man day	16	18	5	19	7.4	19

Table 18. Yield of rice as affected by the method of crop establishment, weed control and soil type (in kg/ha treatment means).

Crop Establishment	Weed control	Well drained soil	Soil types Imperfectly drain soil	Poorly drained soil
TP*	Chemical	5152	5290	5520
	No weeding	4948	5182	3312
	Rot weeding	4876	5336	5142
RS	Chemical	4968	5014	3128
	No weeding	4160	4232	3220
	Rot weeding	4186	4140	3312
BC	Chemical	4832	4878	3174
	No weeding	4094	4002	3128
	NI*	4186	4048	3083
	N2	4268	4242	3266
	N3	4140	4166	3325
	RI	4278	4140	3358
	R2	4022	4262	4170
	R3	3213	3103	4288
Varieties - Chemical Weed control				
	34-6	5060	4244	5474
	34-8	5190	5106	5612
	11/11	5513	5462	5704
	94/1	6348	6072	4250
	LD-66	4260	4252	4324

N* N fertilizer rates

NI-65 kg N/ha (Deptl. recommendation)
N2-1.5 N - 97 kg N/ha
N3-2N-130 kg N/ha

R - See - rates

RI - 2 bushels/ac (109.0 kg/ha)
R2 - 3 " (163.5 kg/ha)
R3 - 4 " (218.0 kg/ha)

Table 19. Proposed agronomy trials at Paranthan 1978-79 crop year.

Maha (Rice Component Technology)

Rice Variety test	7 selection
Weed control	chemical vs. manual
Fertility	rate vs. split application
Mechanization	thresher

Meda (Additional crop using residual soil moisture)

Green gram

Ground nut

Cowpea

Sesame

Yala (Additional crop using Yala rains)

Green gram

Ground nut

Cowpea

Sesame

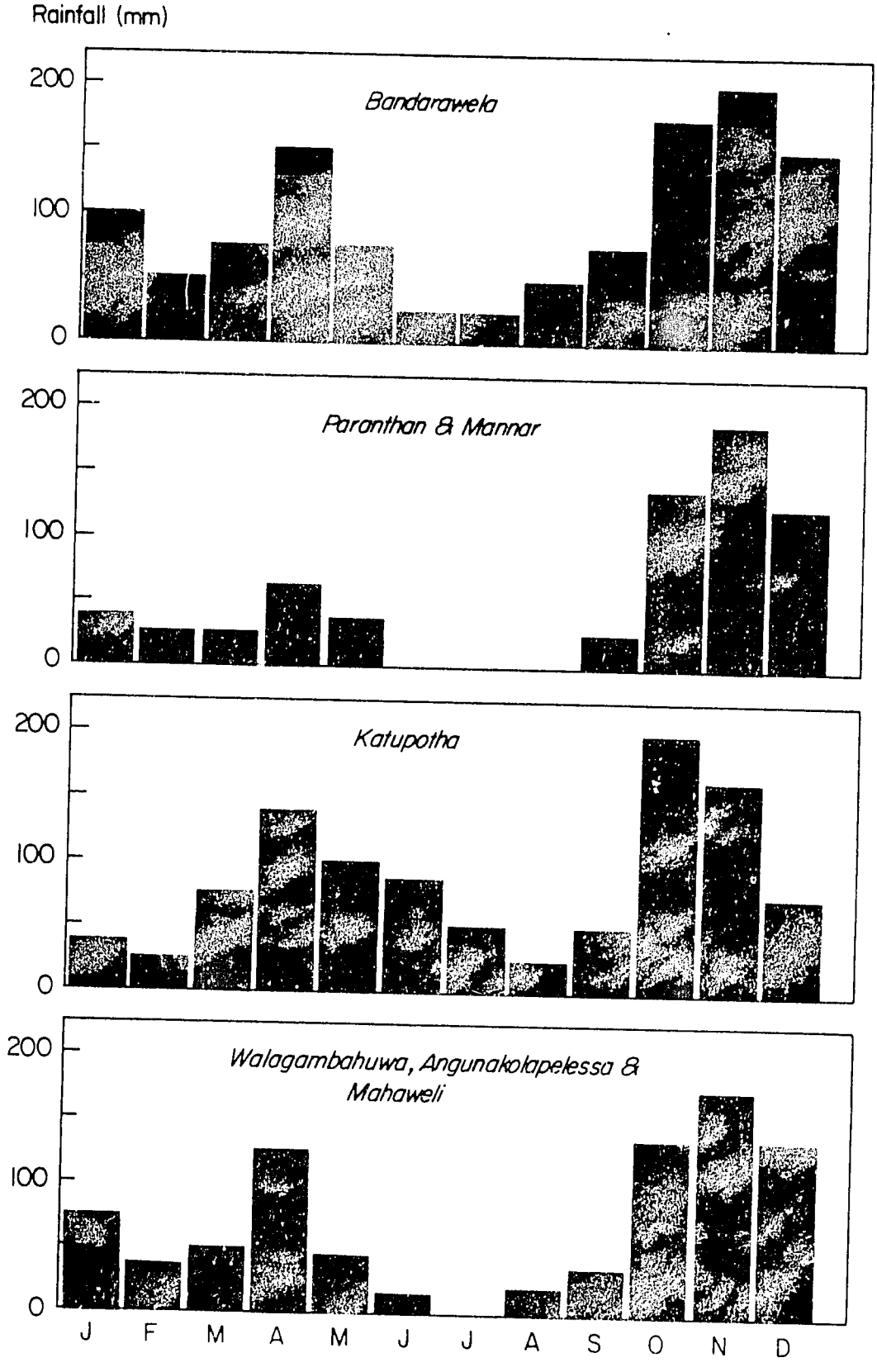


Fig. 1. Minimum 75% probable rainfall distribution for cropping systems study areas.

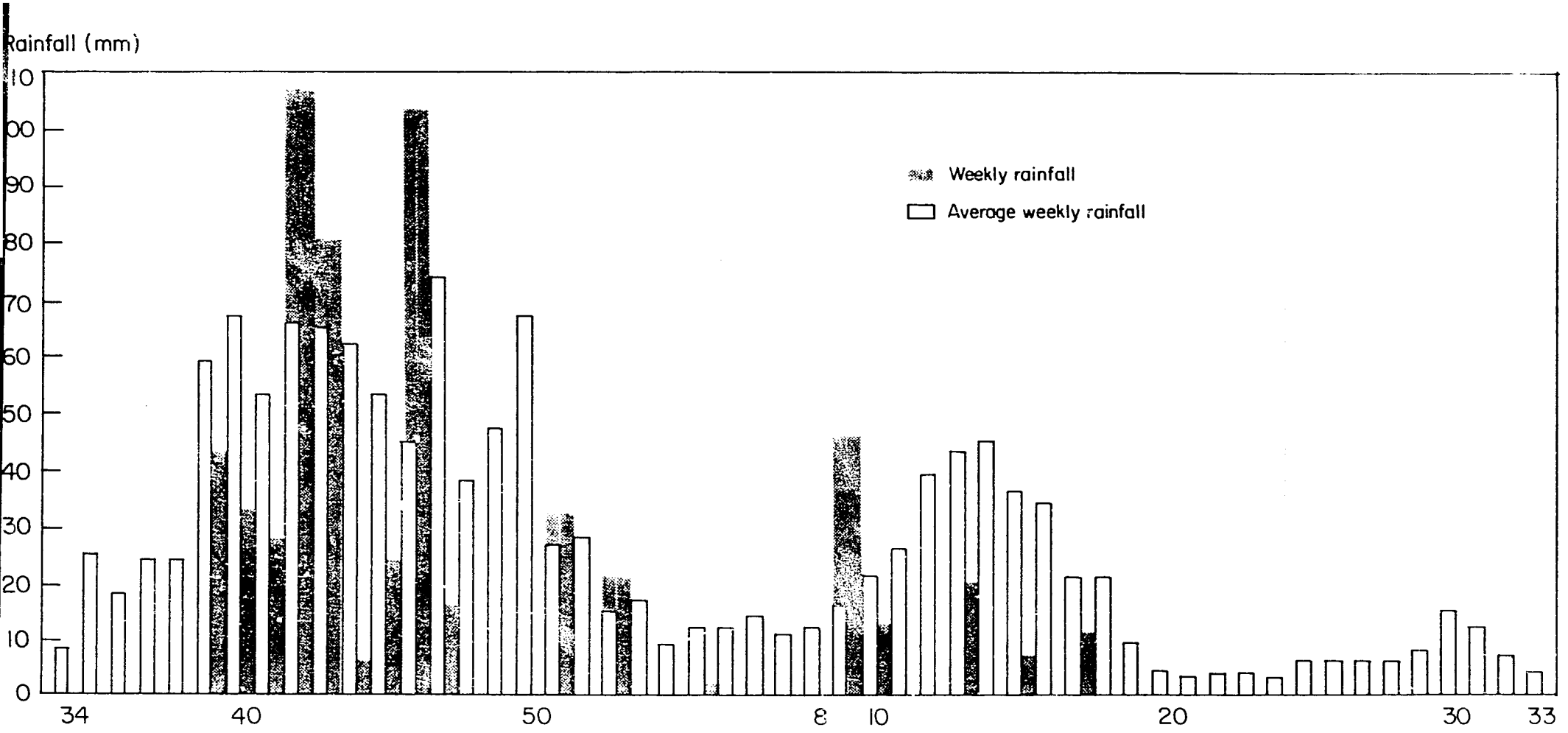


Fig. 2. Weekly rainfall distribution at Walgambahuwa 1977/78.

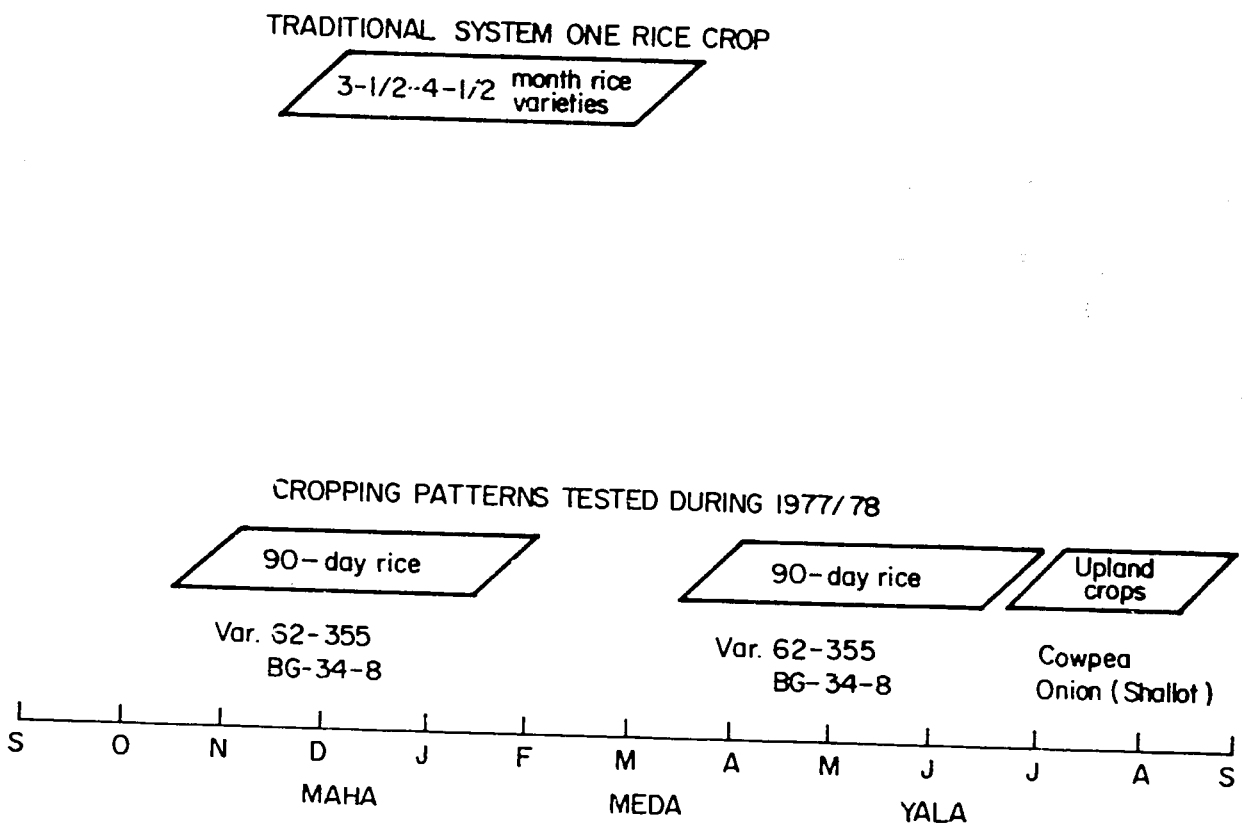


Fig. 3. Tradiational and experimental cropping patterns evaluated at Walagambahuwa in 1977/78.

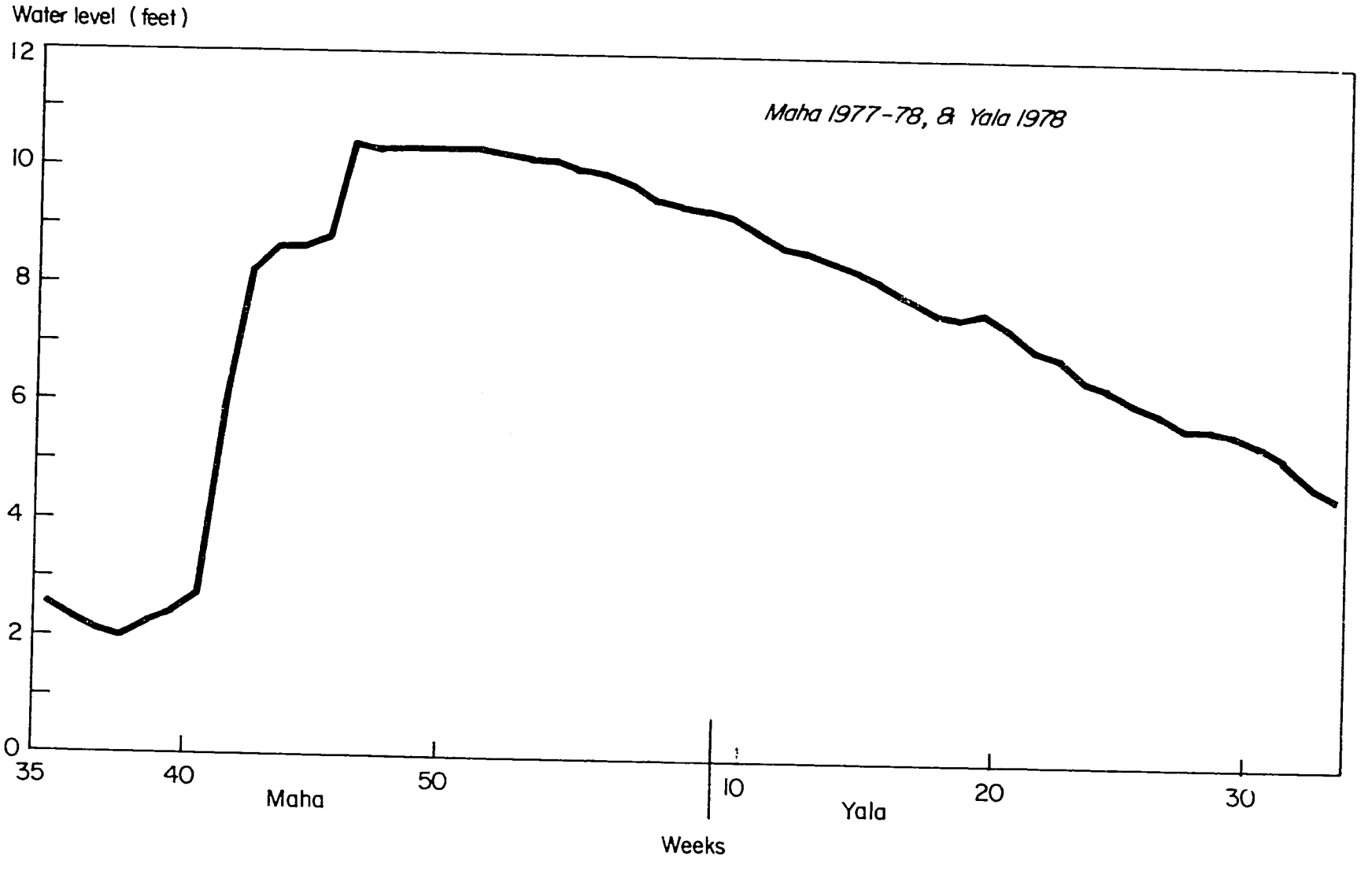


Fig. 4. Water level of walagambahuwa tank, Maha 1977/78 and Yala 1978.

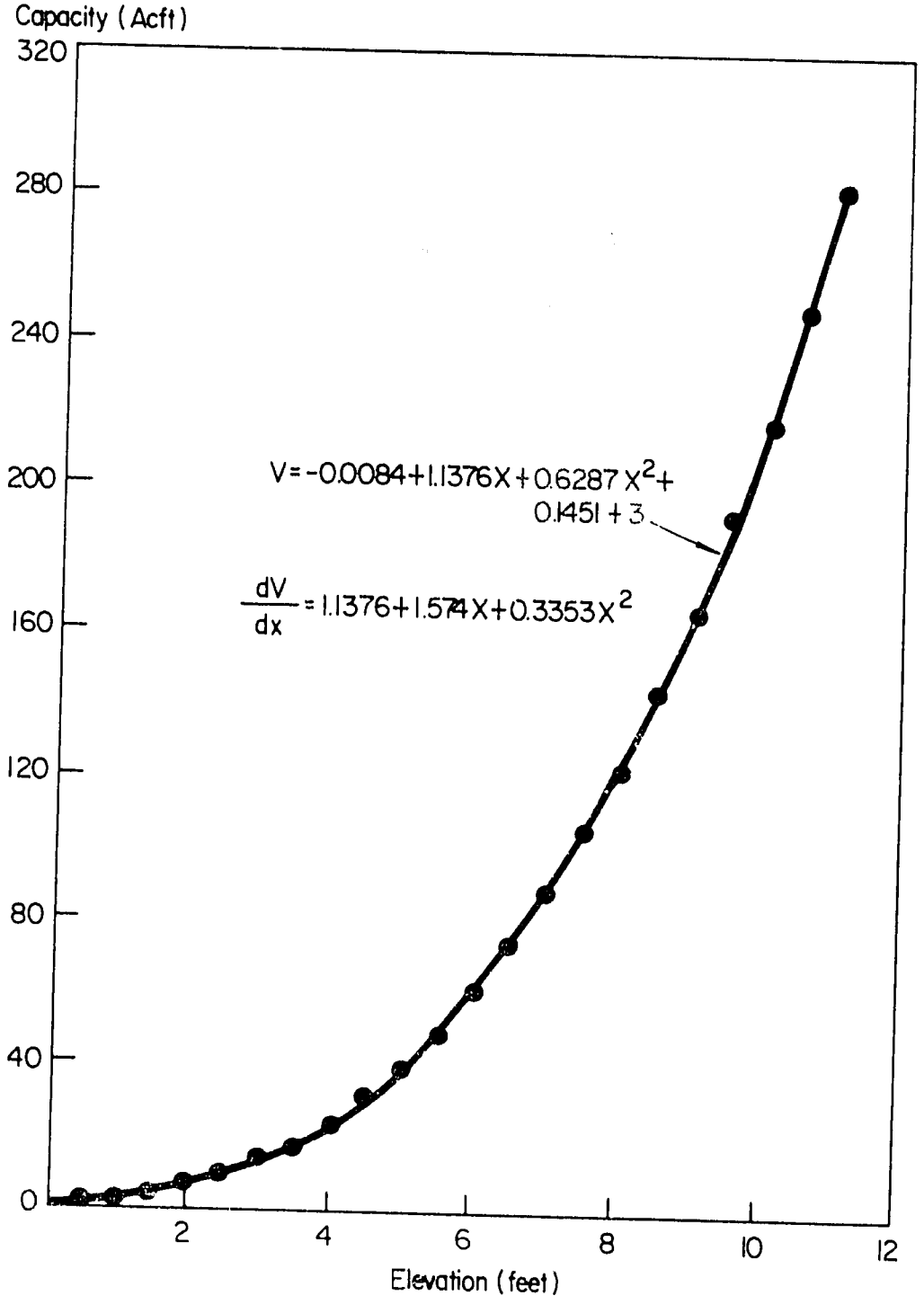


Fig. 5. Elevation capacity curve for Walagambahuwa tank. (Prepared by Land and Water Use Division)

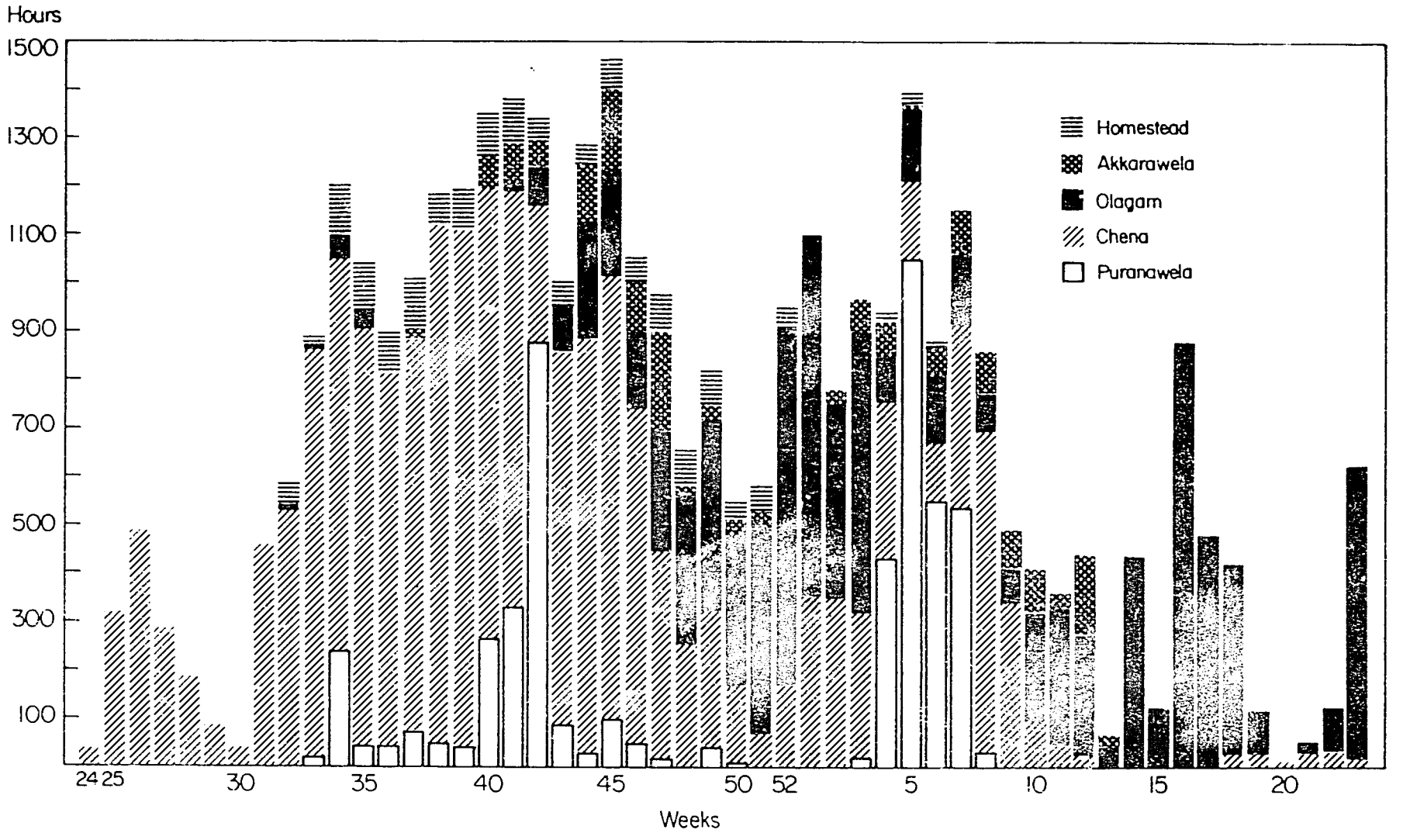


Fig. 6. Weekly labor utilization for various enterprises, twenty farm families, Walagambahuwa, 1977/78.

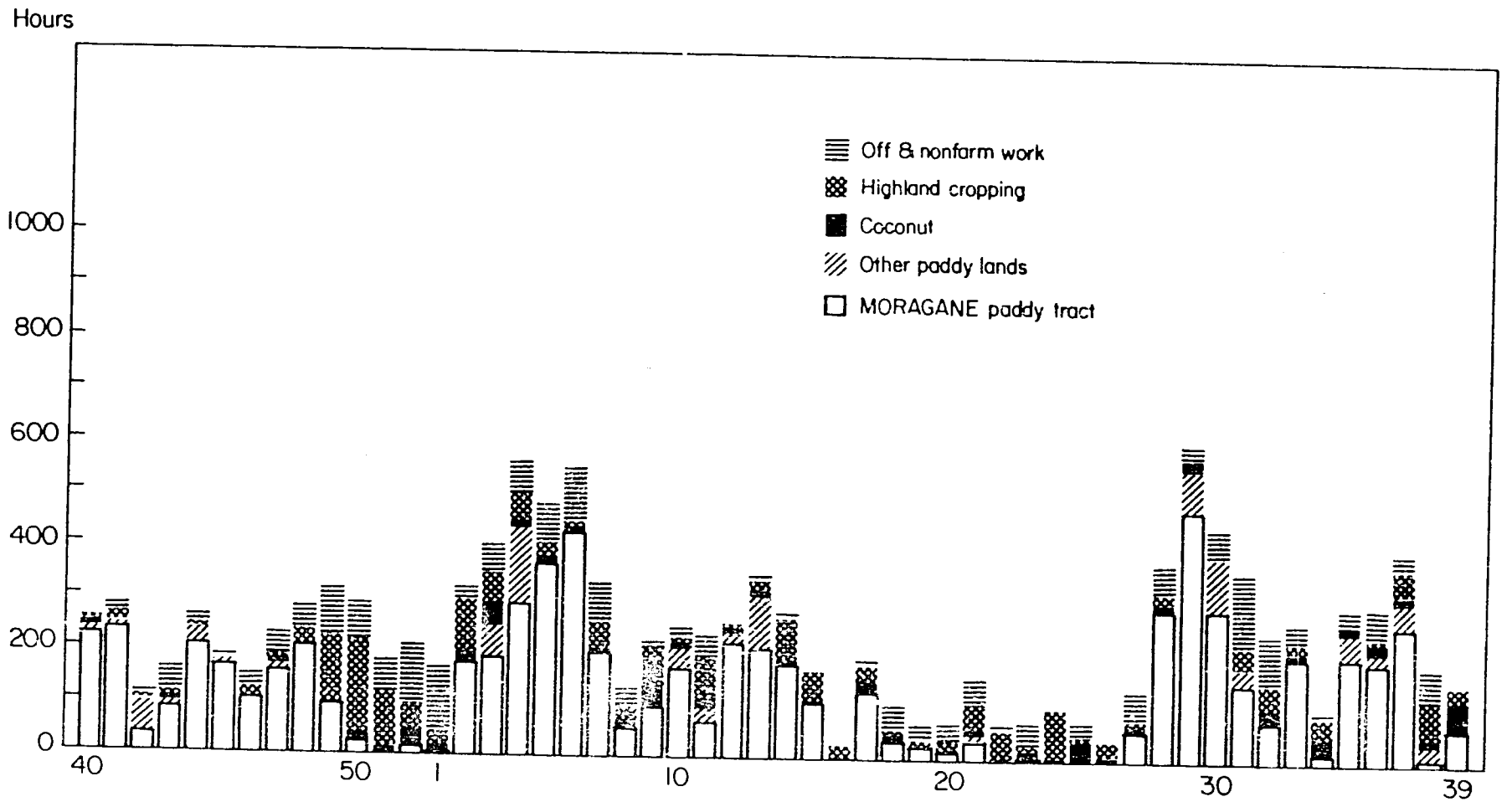


Fig. 7. Weekly labor utilization for various enterprises, seven farm families, Moragane, 1976/77.

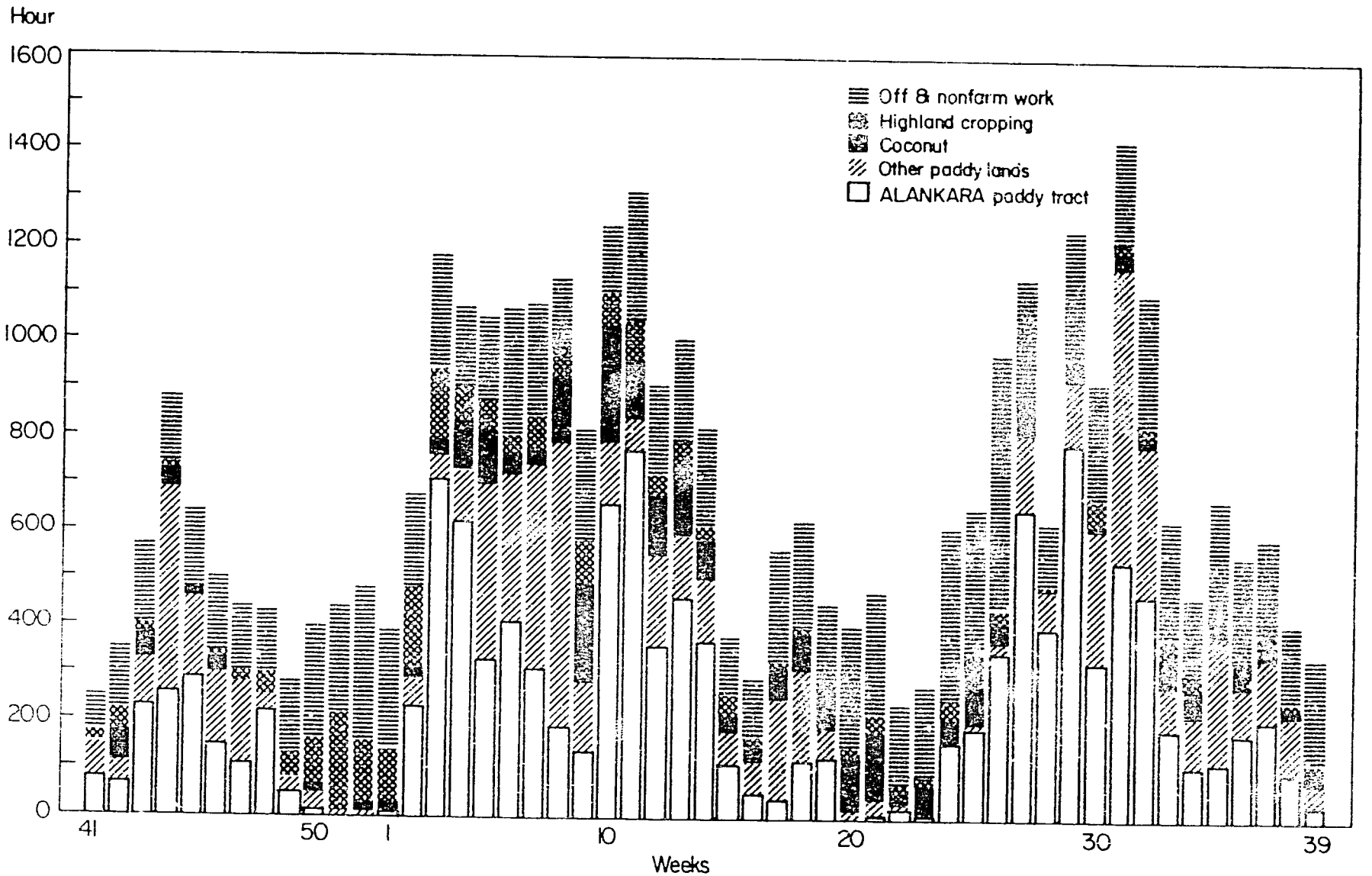


Fig. 8. Weekly labor utilization for various enterprises, ten farm families, Alankara, 1976/77.

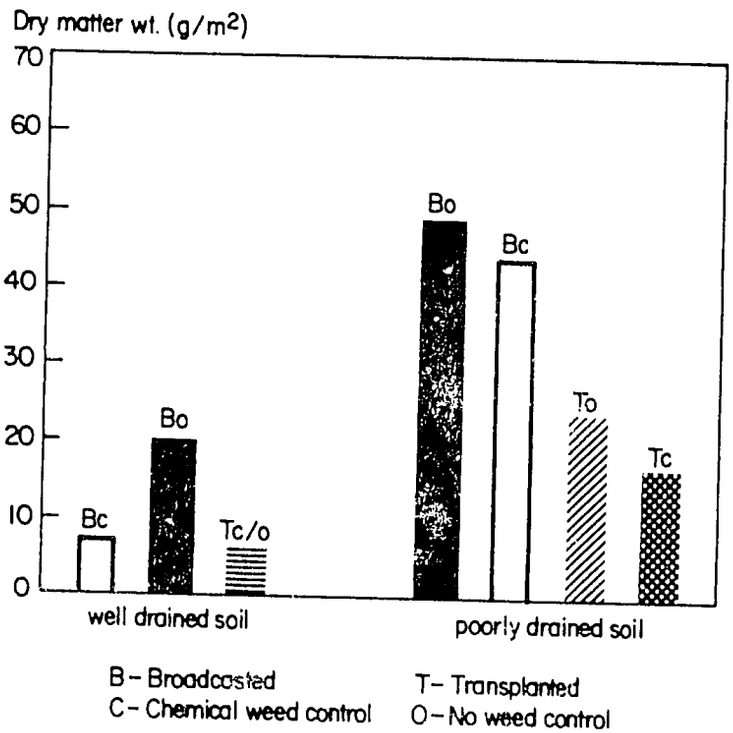


Fig. 9. Weed growth in relation to landscape (25 days after crop establishment).

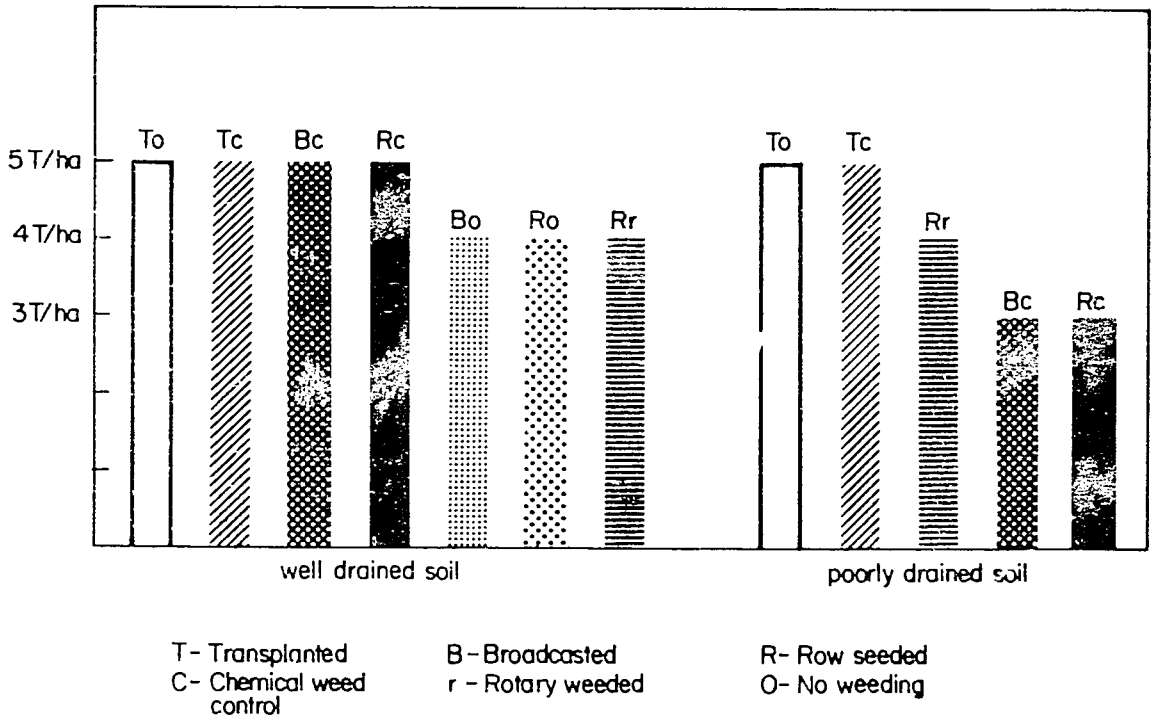


Fig. 10. Yield - moisture regime landscape.

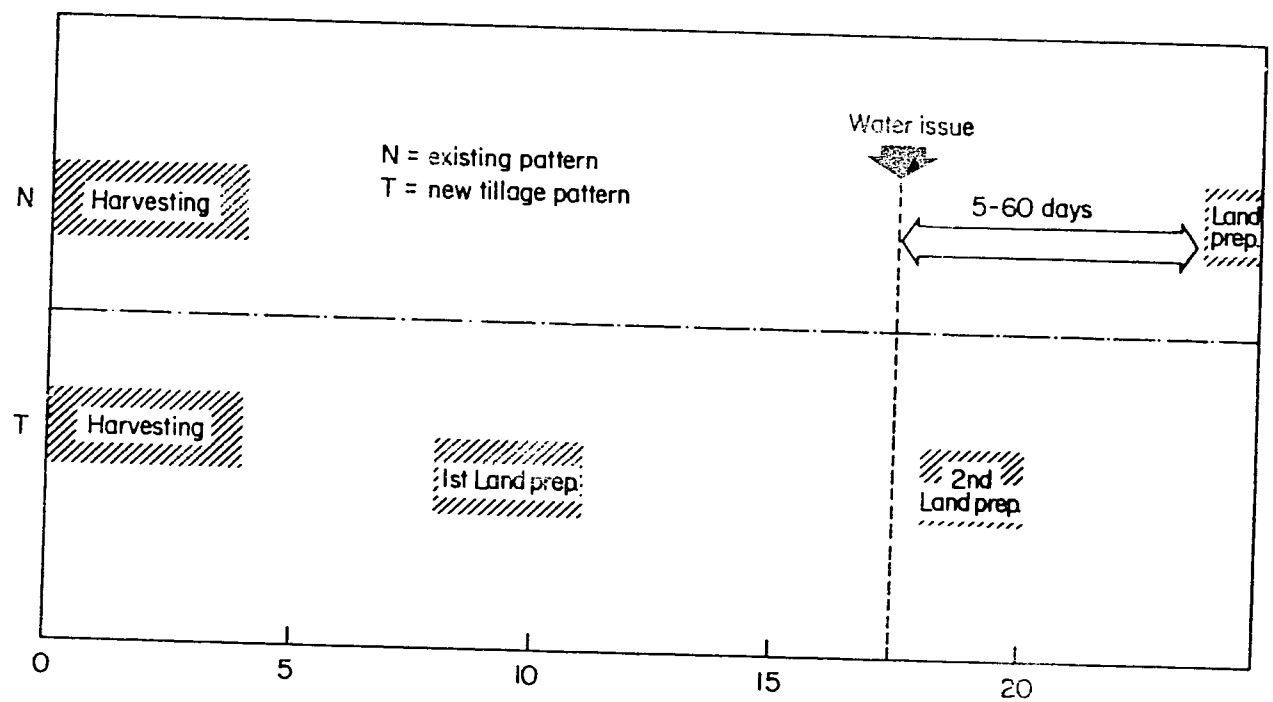


Fig. 11. New tillage pattern.

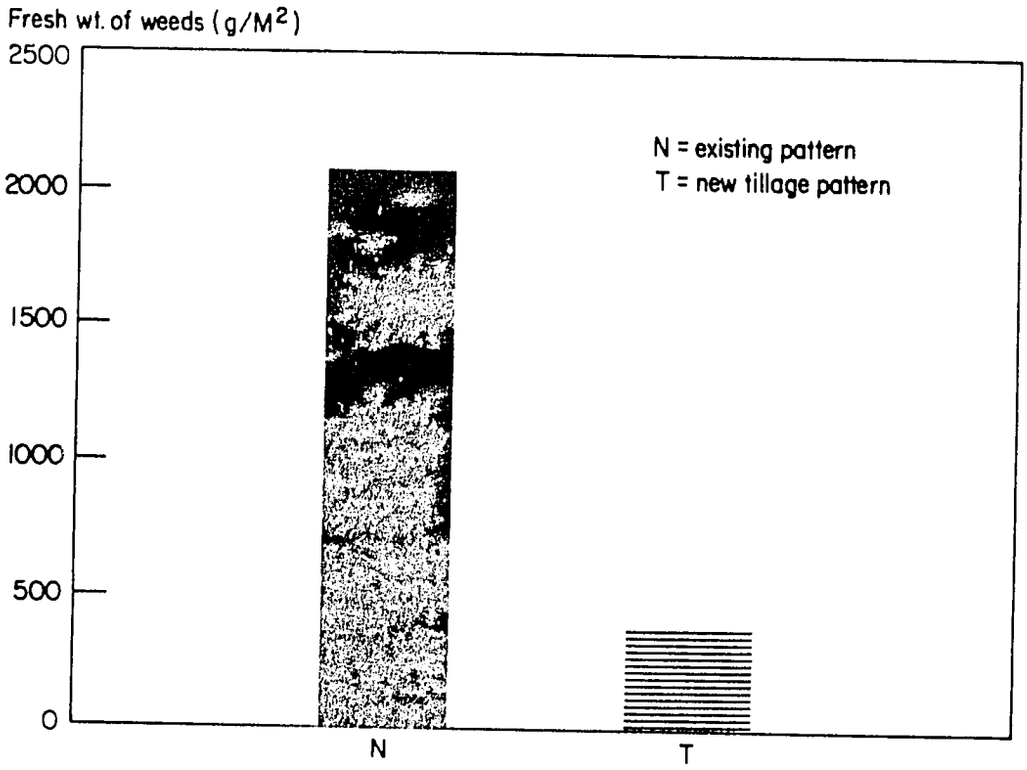


Fig. 12. Weed growth in relation to tillage.

PROGRESS OF THE CROPPING SYSTEMS RESEARCH IN KOREA

Yong Hwa Shin[1/]

Introduction

The Korean Agricultural Sector Study Team has identified inadequate biological technology as one of the most important long term constraints on growth and development of Korean agriculture. This coupled with a high population density, a shift of rural people to the industralized centers, limited arable land resources and so on.

The cropping systems research projects are designed to test new techniques with the goal of alleviating the major constraints on improved land utilization for crop production. Main directions of cropping systems research are:

1) expanding double cropping on paddy land in the northern region
2) developing wheat cultivation on paddy land in the southern region
3) developing mechanization to reduce labor requirements
4) standardizing cropping systems by regions

Most of the cropping systems research is handled at three Crops Experiment Stations, the Wheat and Barley Research Institute and nine Provincial Offices of Rural Development. The Institute of Agricultural Sciences and Production Economic Research Office are also jointly involved in cropping systems research to solve soil, insect and diseases, and socio-economic problems.

These research organizations are within the Office of Rural Development (ORD) which serves as the biggest research organization responsible for improving farming technique and rural living standards.

Three Crops Experiment Stations are mainly concerned with rice breeding and cultural improvement research: the Crops Experiment Station at Suweon located in the northern region, the Honam Crops Experiment Station at Iri in the southwestern region, and the Yeongnam Crops Experiment Station at Milyang in the southeastern region.

[1/] Research Coordinator, Cropping Systems Program, Office of Rural Development, Suweon 170, Korea.

The Wheat and Barley Research Institute is newly established at Suweon and carries out wheat and barley breeding and cultural improvement research programs. The nine Provincial Offices of Rural Development are extensions of the main experiment stations and research institutes of ORD, and conduct applied research at the provincial level.

Each organization has its own specific objectives related to the environmental and ecological conditions prevailing within its region. However, all of the cropping system research is coordinated at the national level to avoid unnecessary duplication of research activities.

Progress of Cropping Systems Research

In 1977, the Office of Rural Development conducted 52 research titles on cropping systems, 26 of which are new and 26 continued from prior years. Some research results accomplished in 1976 and 1977 are as follows:

1. Studies on fertilizer application in rice-barley double cropping on paddy land.

This study was conducted to determine the effect of phosphate under the rice-barley double cropping system at the Yeongnam Crops Experiment Station.

Whether or not phosphate was applied to rice, the phosphate application to barley shortened heading date, and increased dry weight, root activity, leaf area and heads of barley. Barley yield increased greatly with higher phosphate application (Table 1).

When phosphate was applied to rice, there was no response on barley. This suggests that phosphate applied to paddy soils reverts to an insoluble condition after draining, thus giving no residual effects on barley.

Rice yield also decreased when no phosphate was applied to both preceding barley and rice, however it was not as large as the depression of barley yield.

2. Weed (water-foxtail) control in barley cultivation on paddy land.

This study was conducted to control the weeds, mainly water-foxtail (Alopecurus aquoualis var amurensis) affecting barley on paddy land at the Jeonbug Provincial Office of Rural Development.

The results of the herbicide effects of the water-foxtail control and barley yield are shown in table 2.

The relationship between barley yield and the number of water-foxtail plants showed a highly significant correlation with the second regression curve the negative way.

Among 12 herbicides tested, Herban gave the best control of water-foxtail, and did not cause a yield reduction of barley, even when water-foxtail was already established at the nearly two-leaf stage when herbicide was applied.

Lasso and Machete emulsions were also recommendable herbicides, because the small yield reductions by these herbicides were of less value than the cost of hand weeding (Table 3).

3. A comparative study on the economics of soybean production in different cropping patterns.

The economics and techniques of soybean production were studied on 198 selected farms, 50 of which are demonstration cooperative farms and 148 were ordinary farms.

Average yield of soybeans in inter-cropping were lower than single cropping by 9 percent in the ordinary farms, while by only 5 percent in the demonstration cooperative farms (Table 4). In demonstration cooperative farms, the average net income rate of single cropping was 28.1 percent and that of inter-cropping 29.8 percent, while in ordinary farms the net income rate of single cropping was 13.7 percent and that of inter-cropping 11.1 percent.

Soybean yields were generally low on all farms, even when single cropped, indicating the need for additional research on variety and cultural improvement.

4. Cropping patterns on paddy land in each region.

This study is conducted to establish standard cropping systems in each region by the Interdisciplinary Committee on Cropping Systems Research, ORD.

Korea is divided into 7 regions and 23 subregions, based on climate and topography. This regional division is modified from one originally established by the Korea Rural Economic Institute.

The regional distribution of the country is shown in figure 1, and land area, climate, soils distribution and land utilization in each region and subregion in tables 5, 6, 7 and 8 respectively.

In order to establish cropping patterns on paddy land in each region, field experiments were conducted at the three Crops Experiment Stations and Provincial Offices of Rural Development. The newly improved crop varieties and cultural techniques were introduced and compared with conventional cultural practices.

Cropping patterns and estimated crop yields in each region, determined from the experiment and other field survey results, are outlined in table 9.

In the mountain region, there are only two crop patterns: single rice cropping and rice-forage crop (rye). It is quite simple compared with the South Coast region.

There are eleven alternative cropping patterns, other than single rice cropping in the South Coast region. Horticultural crops such as peas strawberry, garlic, onion, lettuce in vinyl house, food grains such as barley, naked barley, beer barley, wheat and rape (one of the oil crops) are introduced before or after rice cultivation.

This study is now in a preliminary stage, and will be continued on a long term basis to collect more results, especially socio-economic conditions in both experimental and farmer's fields, to establish standard cropping pattern recommendations for each region and subregion.

Table 1. Yields of brown rice and barley under different level of phosphate application.

Phosphate application		Yield (ton/ha)			
Rice	Barley	Brown rice	Index	Barley	Index
P_0	P_0	4.31	93	0.73	36
P_1	P_0	4.47	96	0.83	41
P_2	P_0	4.61	99	0.77	38
P_0	P_1	4.53	97	1.89	91
P_1	P_1	4.66	100	2.03	100
P_2	P_1	4.65	100	2.07	102
P_0	P_2	4.58	98	2.53	125
P_1	P_2	4.59	99	2.47	122
P_2	P_2	4.66	100	2.51	124

P_0 : No phosphate application

P_1 : Phosphate 40 kg/ha

P_2 : Phosphate 80 kg/ha

Table 2. The effect of herbicides on water-foxtail control and barley yield on paddy land.

Treatment		Number of weeds/m^2	Percent of weeds	Barley yield (ton/ha)	Barley reduction index
No-weeding		2,043	100	2.60	27
Hand weeded check		105	6	3.27	0
Tok	200 cc	1,952	96	2.11	41
Machete	250 cc	567	28	3.03	15
Machete	3 kg	990	49	2.97	17
Herban	170 g	234	11	3.26	9
CAT	100 cc	515	25	2.96	18
HE 314	1,000 cc	602	30	2.94	18
Saturn-S	2,000 cc	928	45	2.39	33
Igran	300 cc	792	39	2.46	31
C-288	30 kg	815	40	2.55	29
Lasso	150 cc	368	18	3.05	15
Lasso	1.5 kg	399	20	2.75	23
Select	600 cc	820	40	2.39	33

Table 3. Barley yield and income in different weed control.

Treatment	Barley yield (ton/ha)	Gross return	Management expense	Income	Income index
		----------(1,000 won/ha)-------			
No-weeding	2.60	319.3	158.0	161.3	94
Hand weeded check	3.27	401.6	230.0	171.6	100
Machete 250 cc	3.03	372.1	170.0	202.1	118
Herban 170 g	3.26	400.4	170.0	230.4	134

Table 4. Soybean yield and net income on single-cropping and inter-cropping.*

I t e m	Ordinary Farms		Demonstration cooperative farms	
	Single cropping	Inter cropping	Single cropping	Inter cropping
Soybean yield (ton/ha)	1.37	1.24	1.78	1.68
Yield index	100	91	100	95
Gross return (1,000 won/ha)	381.2	432.1	490.3	553.0
Soybean	381.2	343.1	490.3	466.9
Inter-crop	-	89.0	-	86.1
Production cost	329.0	384.0	352.5	388.5
Net income	52.2	48.1	137.8	164.5
Net income rate (%)	13.7	11.1	28.1	29.8

* Intercropping included corn, sorghum wild sesame etc.

Table 5. Land area in each region and subregion.

Symbol	Region	Subregion	Area (1,000 ha)	Percentage of area
M_1	Mountain	Northern Mountain	897	9.1
M_2	"	Southern Mountain	118	1.2
G_1	Gyeonggi	Gyeonggi Inland	877	8.9
G_2	"	Northern Gyeonggi	579	5.9
G_3	"	Southern Gyeonggi	375	3.8
C_1	Chyngcheong	Seodang Peninsula	310	3.1
C_2	"	Chungcheong Inland	332	3.4
C_3	"	Geum River Basin	662	6.7
H_1	Honam	Honam Plain	503	5.1
H_2	"	Noryeong Mountain	78	0.8
H_3	"	Honam Inland	434	4.4
H_4	"	Gwangla Plain	285	2.9
H_5	"	Southwest Coast	363	3.7
S_1	South Coast	South Coast	423	4.3
S_2	"	Jeju Island	182	1.8
S_3	"	South Coast Inland	749	7.5
Y_1	Yeongnam	Gyeongnam Inland	231	2.3
Y_2	"	Nagdong River Basin	1,213	12.3
Y_3	"	Gyeongbug Inland	349	3.5
E_1	East Coast	Southern East Coast	414	4.2
E_2	"	Middle East Coast	365	3.7
E_3	"	Northern East Coast	133	1.3
E_4	"	Ulreung Island	7	0.1

Table 6. Climate in each region and subregion.

Subregion	Average Temp. (°C)					Min. Temp.(°C)	Rainfall (mm)				
	Annual	Jan.	Apr.	Jul.	Oct.	Jan.	Annual	Spr.	Sum.	Aut.	Win.
Mountain											
M_1	10.8	-6.3	10.5	24.9	12.9	-13.1	1,035	170	620	195	60
M_2	11.5	-4.0	10.7	25.6	12.8	-10.7	1,230	215	670	245	95
Gyeonggi											
G_1	10.3	-7.1	10.6	24.8	12.9	-13.8	1,270	215	770	250	65
G_2	11.1	-4.9	10.4	24.7	13.7	-9.8	1,255	210	750	215	70
G_3	11.5	-0.4	10.4	25.0	13.8	-8.8	1,090	180	625	210	70
Chungcheong											
C_1	11.8	-3.0	10.7	25.1	14.0	-7.8	1,170	195	665	245	70
C_2	11.3	-5.0	11.0	25.4	12.9	-11.1	1,125	210	645	225	70
C_3	12.0	-3.7	11.3	25.8	13.4	-9.0	1,170	210	660	220	75
Honam											
H_1	13.2	-1.2	11.4	26.0	14.2	-5.7	1,155	205	605	235	100
H_2	13.1	-	-	-	-	-	1,320	230	720	260	110
H_3	13.0	-1.0	11.9	25.6	14.6	-5.8	1,310	275	675	255	95
H_4	12.9	-1.0	11.4	26.0	14.5	-5.3	1,260	230	645	265	110
H_5	13.6	1.3	11.7	25.2	16.0	-2.6	1,195	250	570	255	115
South Coast											
S_1	14.2	1.7	12.7	24.6	16.8	-2.7	1,360	330	630	325	85
S_2	15.1	5.1	13.0	14.9	17.5	1.8	1,560	365	665	350	180
S_3	13.5	-0.1	12.5	26.2	15.6	-5.3	1,295	275	670	275	80
Yeongnam											
Y_1	12.4	-1.9	11.6	25.9	13.7	-7.6	1,200	220	665	255	80
Y_2	12.2	-2.8	11.9	26.0	14.0	-6.6	1,030	210	565	210	65
Y_3	11.3	-4.2	10.8	24.9	12.9	-10.0	915	180	505	175	60
East Coast											
E_1	13.1	0.2	12.1	24.7	15.2	-4.8	1,095	190	475	275	95
E_2	12.5	-0.6	11.6	24.1	14.8	-4.8	1,130	185	485	320	135
E_3	11.8	-2.4	11.1	24.0	14.3	-7.0	1,130	180	535	325	80
E_4	12.0	0.6	10.2	22.1	15.0	-1.9	1,490	240	370	420	450

Table 7. Soils distribution in each region and subregion.

Subregion	Soils distribution rate (%)										
	Sand dune	Fluvio-marine plains	Flood plains	Inland alluvial plains	Narrow valley	Rolling land	Mt. foot slope	Hilly land	Mountain-ous land	Mt. plateau	Others
Mountain											
M_1	-	-	1.9	0.6	7.7	4.5	3.4	4.9	75.4	1.1	0.5
M_2	-	-	1.8	1.0	10.5	2.4	4.1	5.7	74.4	0.1	-
Gyeonggi											
G_1	-	-	3.8	2.3	10.2	12.2	2.0	11.9	56.7	0.4	0.5
G_2	-	6.0	7.2	7.8	14.5	26.9	1.9	12.8	21.7	-	1.2
G_3	0.3	8.6	2.9	10.3	15.2	33.9	1.3	11.5	14.2	-	1.8
Chungcheong											
C_1	0.7	9.8	2.2	7.1	12.9	38.1	2.1	11.6	12.2	-	3.3
C_2	-	-	5.0	5.5	12.4	14.5	4.4	11.6	42.0	3.7	0.9
C_3	-	1.5	6.3	6.4	13.9	20.1	2.3	13.5	35.0	-	1.0
Honam											
H_1	0.3	18.5	2.0	8.4	10.2	17.6	2.9	6.2	32.5	-	1.4
H_2	-	-	1.8	1.2	11.5	4.1	0.9	11.9	68.3	0.3	-
H_3	-	1.4	2.5	4.0	14.2	4.9	3.5	10.3	58.9	0.1	0.2
H_4	-	0.6	4.8	12.9	12.1	9.7	2.5	6.8	50.4	0.1	0.1
H_5	0.7	10.1	0.6	6.6	8.8	25.9	3.9	10.9	31.3	-	1.2
South Coast											
S_1	0.3	5.6	0.9	5.9	9.2	11.2	3.8	10.8	51.7	0.1	0.5
S_2	1.2	0.2	-	-	-	50.7	23.8	0.1	12.9	11.0	0.1
S_3	-	3.0	5.6	6.8	11.9	5.5	1.3	15.2	49.5	0.2	1.0
Yeongnam											
Y_1	-	-	3.1	1.6	13.2	2.7	4.3	9.4	65.7	-	-
Y_2	-	-	6.5	5.1	11.9	8.1	1.7	12.7	53.5	0.1	0.4
Y_3	-	-	2.2	1.2	9.5	6.8	2.0	11.0	67.0	0.3	-
East Coast											
E_1	0.5	2.2	4.0	5.7	8.7	7.0	2.2	15.5	53.8	0.3	0.1
E_2	0.6	1.2	1.5	0.3	6.0	8.3	1.1	9.0	71.0	0.9	0.1
E_3	1.2	1.4	3.3	1.3	5.7	15.3	1.1	9.8	59.8	0.7	0.4
E_4	1.5	0.1	-	-	2.8	3.6	5.8	3.5	82.7	-	-

Table 8. Land utilization in each region and subregion.

Subregion	Area cultivated land (1,000 ha)	Distribution rate (%)		Land area per farm household (ha)	Paddy land utilization rate (%)
		Paddy land	Upland		
Mountain					
M_1	76	25	75	1.12	104
M_2	17	53	47	0.90	130
Gyeonggi					
G_1	111	47	53	1.19	107
G_2	161	62	38	1.18	115
G_3	149	65	35	1.18	127
Chungcheong					
C_1	114	60	40	1.02	128
C_2	88	50	50	1.14	124
C_3	180	58	42	0.98	137
Honam					
H_1	214	71	29	0.96	157
H_2	12	54	46	0.87	142
H_3	95	68	32	0.85	153
H_4	86	68	32	0.83	161
H_5	132	54	46	0.95	139
South Coast					
S_1	104	56	44	0.67	147
S_2	50	2	98	0.91	101
S_3	178	67	33	0.85	155
Yeongnam					
Y_1	37	67	33	0.79	152
Y_2	258	59	41	0.93	142
Y_3	52	36	64	1.08	110
East Coast					
E_1	77	65	35	0.84	137
E_2	32	43	57	0.90	110
E_3	13	63	37	1.17	101
E_4	1	4	96	-	103

Table 9. Cropping patterns on paddy land in each region.

Region (Exp. site)	Cropping Pattern												Estimated yield (ton/ha)	
	Jan. EML*	Feb. EML	Mar. EML	Apr. EML	May EML	Jun. EML	Jul. EML	Aug. EML	Sept. EML	Oct. EML	Nov. EML	Dec. EML	Rice	Before/after crop
Mountain (Cheolweon)						Rice							5.0	-
	Forage crop (rye)					Rice				Forage crop			5.0	30.0
Gyeonggi (Suweon)						Rice							6.2	-
	Forage crop (rye)					Rice				Forage crop			6.2	31.0
			Potato			Rice							4.3	18.0
			Peas			Rice							4.3	5.1
	Barley					Rice				Barley			4.3	4.1
Chungcheong (Yuseong)						Rice							6.5	-
	Forage crop (rye)					Rice				Forage crop			6.5	37.5
			Potato			Rice							5.3	18.9
			Peas			Rice							5.3	5.7
	Strawberry					Rice				Strawberry			5.3	4.4
	Garlic					Rice					Garlic		5.3	7.2
	Barley					Rice				Barley			5.3	2.6
	Naked Barley					Rice				Naked Barley			5.3	2.6
Honam (Gwangju)						Rice							6.1	-
	Forage crop (rye)					Rice				Forage crop			6.1	34.5
			Potato			Rice							5.0	13.7
			Peas			Rice							5.0	2.6

* E, M, L, designates early, mid, and last 10-day period of month.

Table 9. (Cont'd)

Region (Exp. site)	Cropping Pattern												Rice	Before/After crop
	Jan. EML	Feb. EML	Mar. EML	Apr. EML	May EML	June EML	Jul EML	Aug. EML	Sept EML	Oct. EML	Nov. EML	Dec. EML		
	Strawberry						Rice				Strawberry		5.0	14.2
	Garlic						Rice			Garlic			5.0	10.7
	Onion						Rice			Onion			5.0	26.0
	Rape						Rice				Rape		5.0	2.9
	Naked Barley						Rice				Naked Barley		5.0	2.7
	Wheat						Rice				Wheat		5.0	2.8
South Coast (Jinju)							Rice						6.6	-
	Forage crop (rye)						Rice				Forage crop		6.6	34.5
		Potato					Rice						5.3	18.0
		Peas					Rice						5.3	2.6
	Strawberry						Rice				Strawberry		5.3	14.2
	Garlic						Rice				Garlic		5.3	10.1
	Onion						Rice				Onion		5.3	42.6
							Rice				Vinyl house (Lettuce)		5.3	42.0
	Rape						Rice				Rape		5.3	2.5
	Barley						Rice				Barley		5.3	5.1
	Naked Barley						Rice				Naked Barley		5.3	4.4
	Wheat						Rice				Wheat		5.3	3.9
	Beer barley						Rice				Beer Barley		5.3	4.4

Table 9. (Cont'd)

Region (Expt. site)	Cropping Pattern												Estimated Yield (ton/ha)	
	Jan EML	Feb EML	Mar EML	Apr EML	May EML	Jun EML	Jul EML	Aug EML	Sep EML	Oct EML	Nov EML	Dec EML	Rice	Before/After crop
Yeongnam (Chilgog)							Rice						6.1	-
	Forage crop (rye)						Rice			Forage crop			6.1	34.5
			Potato				Rice						5.7	18.5
			Peas				Rice						5.7	6.4
	Strawberry						Rice			Strawberry			5.7	14.2
	Garlic						Rice			Garlic			5.7	7.1
		Vinyl house(cucumber)					Rice						5.7	28.7
	Barley						Rice			Barley			5.7	4.0
	Naked Barley						Rice			Naked Barley			5.7	3.7
	Wheat						Rice			Wheat			5.7	3.8
East Coast (Gangneung)							Rice						4.4	-
	Forage crop (rye)						Rice			Forage crop			4.4	34.5
			Potato				Rice						3.9	24.0
			Peas				Rice						3.9	5.0
	Garlic						Rice			Garlic			3.9	8.2
	Barley						Rice			Barley			3.9	4.7

Table 9. (Cont'd)

Region (Exp. site)	Cropping Pattern												Rice	Before/After crop
	Jan. EML	Feb. EML	Mar. EML	Apr. EML	May EML	June EML	Jul EML	Aug. EML	Sept EML	Oct. EML	Nov. EML	Dec. EML		
	Strawberry						Rice				Strawberry		5.0	14.2
	Garlic						Rice			Garlic			5.0	10.7
	Onion						Rice			Onion			5.0	26.0
	Rape						Rice				Rape		5.0	2.9
	Naked Barley						Rice				Naked Barley		5.0	2.7
	Wheat						Rice				Wheat		5.0	2.8
South Coast (Jinju)							Rice						6.6	-
	Forage crop (rye)						Rice				Forage crop		6.6	34.5
		Potato					Rice						5.3	18.0
		Peas					Rice						5.3	2.6
	Strawberry						Rice				Strawberry		5.3	14.2
	Garlic						Rice				Garlic		5.3	10.1
	Onion						Rice				Onion		5.3	42.6
							Rice				Vinyl house (Lettuce)		5.3	42.0
	Rape						Rice				Rape		5.3	2.5
	Barley						Rice				Barley		5.3	5.1
	Naked Barley						Rice				Naked Barley		5.3	4.4
	Wheat						Rice				Wheat		5.3	3.9
	Beer barley						Rice				Beer Barley		5.3	4.4

Table 9. (Cont'd)

Region (Expt. site)	Cropping Pattern												Estimated Yield (ton/ha)	
	Jan EML	Feb EML	Mar EML	Apr EML	May EML	Jun EML	Jul EML	Aug EML	Sep EML	Oct EML	Nov EML	Dec EML	Rice	Before/After crop
Yeongnam (Chilgog)							Rice						6.1	-
	Forage crop (rye)						Rice			Forage crop			6.1	34.5
			Potato				Rice						5.7	18.5
			Peas				Rice						5.7	6.4
	Strawberry						Rice			Strawberry			5.7	14.2
	Garlic						Rice			Garlic			5.7	7.1
		Vinyl house(cucumber)					Rice						5.7	28.7
	Barley						Rice			Barley			5.7	4.0
	Naked Barley						Rice			Naked Barley			5.7	3.7
	Wheat						Rice			Wheat			5.7	3.8
East Coast (Gangneung)							Rice						4.4	-
	Forage crop (rye)						Rice			Forage crop			4.4	34.5
			Potato				Rice						3.9	24.0
			Peas				Rice						3.9	5.0
	Garlic						Rice			Garlic			3.9	8.2
	Barley						Rice			Barley			3.9	4.7

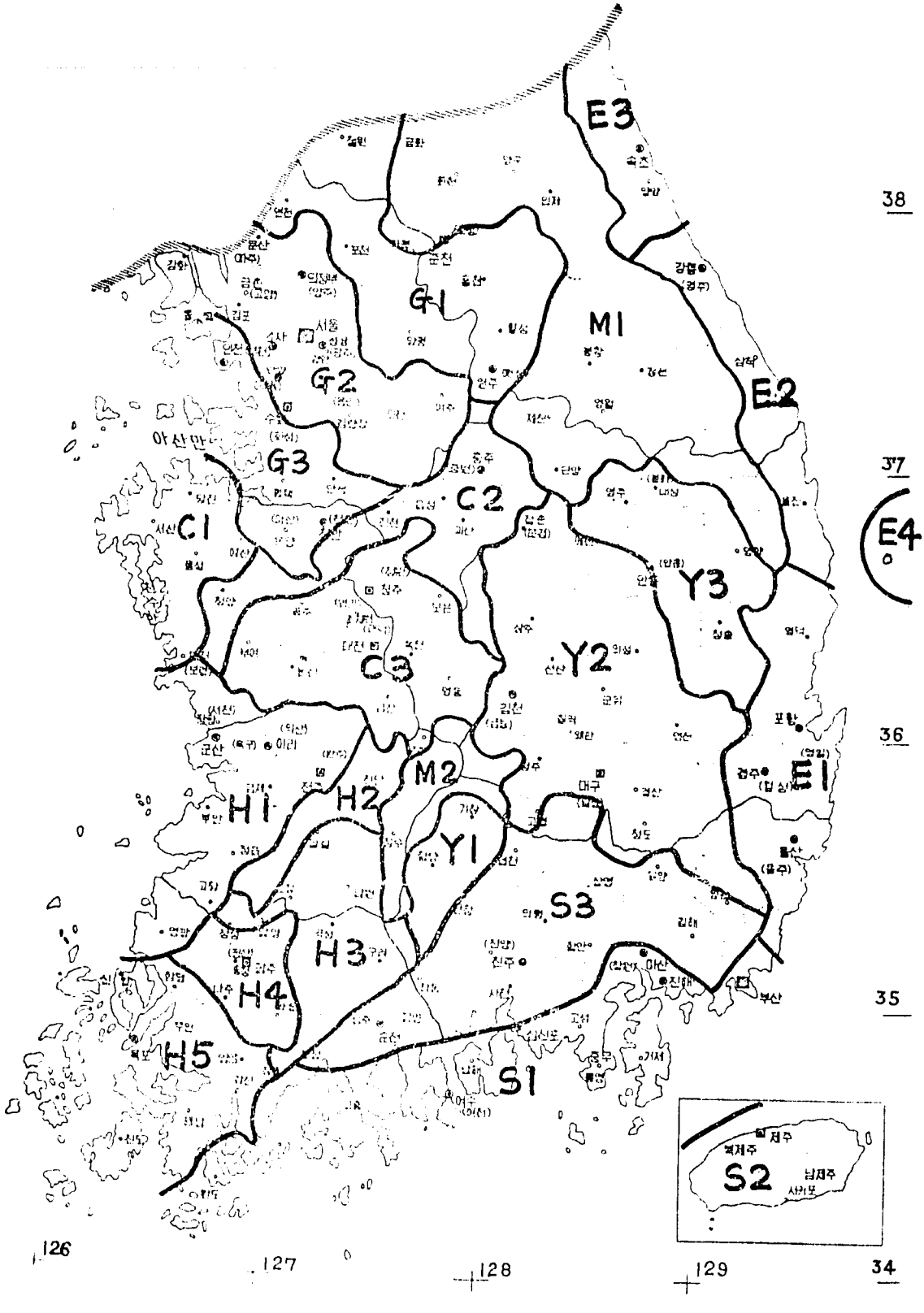


Fig. 1. The regional and subregional distribution of South Korea.

THE NATIONAL PROGRAM ON CROPPING SYSTEMS IN THE PHILIPPINES

Arturo A. Gomez[1/]

Introduction

The cropping system program in the Philippines can be divided into four main categories; namely: (1) development of varieties; (2) development of management practices; ( ) quantification of constraints in farmers' field; and (4) national production programs. I shall devote this paper primarily in discussing varietal improvement. Management practices will be covered by the IRRI report while the production program has been presented in previous meetings. Constraints in farmers field has just started and no results can yet be presented.

An important factor for the success of multiple cropping is the identification of high yielding varieties that are adapted to the specific requirements of intensive cropping system. This required a range of high yielding varieties that vary in growth duration, seedling vigor, grain characteristics, etc. While the breeding programs for rice in the region seriously consider the requirement for intensive cropping, those for the upland crops have been primarily directed towards normal upland culture. Thus in late 1974, IDRC provided financial support for a program to screen upland crops for intensive cropping. The objectives of the program are: (1) to evaluate early generation lines produced by various international breeding centers for characters of major importance in intensive cropping in Asia, (2) to test promising varieties in several Asian agro-climatic zones.

Procedure

Screening at UPLB started in 1975-76 dry season. Breeding materials collected from the international centers and national programs were screened for adaptability to shade and to planting before and after lowland rice.

[1/] Vice Chancellor Academic Affairs, University of the Philippines at Los Baños (UPLB), College, Laguna, Philippines.

In screening after rice, test materials were upland immediately after the rice harvest without tillage. There was no tillage either in screening before rice and test materials were sown at the first rain. Both screenings were conducted simulating rainfed lowland conditions. The test under shade was done in upland, with good tillage and with 40% shading. Promising materials from these tests are then included in the cropping systems network varietal testing program for evaluation in cropping systems research sites in participating countries.

Results

The major accomplishments as of 1977 are the following:

A. Mungbean

Yield trials performed in 1975-77 indicated high adaptability of some mungbean varieties to post-rice paddy planting. Mulching was also observed to increase yield by 76%. Among the elite lines evaluated; Bhacti, CES 55, CES 28 and Dau Mo gave high yields when mulched while CES N-6, CES 14, CES 55 and CES U-1 were top yielders in the unmulched treatment. In the 1977 trials involving 2057 accessions, the average yield obtained was 0.808 ton/ha with a range of 0.025-2.525 tons/ha. The highest yielding accessions along with promising lines are presently entered in replicated yield trials.

For pre-rice planting, a wide variability in flowering was observed. Thus, of the 2057 accessions initially screened, only 53 were identified as good plant types, although some varieties resistant to Cercospora leaf spot were also isolated. The yields obtained from these selections ranged from 0.026-0.807 ton/ha. with a mean of 0.135 ton/ha. All accessions which flower after 45 days have been dropped from this year's trials.

In the test under shade, the average bean yield was only 32% of the potential yield of 1.15 tons/ha. in the open. Some varieties identified to be tolerant to shading are CES 1J-3, CES 1F-3, CES 1T-2, and CES 1K-25(y). Problems of damping-off and powdery mildew were also encountered, although some resistant varieties were isolated.

When intercropped with sugarcane, mungbean yield was relatively low. This was however attributed to interplant competition for growth factors rather than shading alone.

B. Soybean

Twenty elite and 100 promising varieties and lines were initially tested for post-rice cropping. Average yield with mulching was 1.6 tons/ha. compared with 0.78 ton/ha. when left unmulched. The highest yielders were Clark 63 and Williams for the mulched treatment, Lincoln and KE32 for the

unmulched treatment. Top yielders among the promising varieties were CES 16-3, Corsoy, E.G., Special CES 16-42, and Higo-musume. In the succeeding tests, however, excess moisture in the paddies affected seed germination, thus poor performance was observed.

The same entries used in the lowland trial were tested under shade. Yield under shade was only 68% of the yield in the open. Only two varieties of the elite group (UPLB-SY2) and KE 32) and five in the promising group (TGM 305-2, CES 15-4, TGM-7, Hill and CES 13-2) yielded higher than one ton. Succeeding tests seemed to show a one ton/ha. potential yield for soybeans under partial shade.

Trials involving soybean intercropped with sorghum gave a relatively poor average of only 0.229 ton/ha.

C. Cowpea

Nine varieties out of 297 accessions screened for post-rice planting yielded more than 3 tons/ha which compared favorably with yields obtained under upland conditions. Disease resistance was also included in the evaluation.

Eight hundred thirty seven accessories were screened for pre-rice planting. Fresh pod and dry bean yields ranged from 0.03 to 9.64 tons/ha. with a mean of 1.95 tons/ha and from 0.01 to 1.47 tons/ha with a mean of 0.20 ton/ha., respectively. The results indicated that for pre-rice cropping, cowpea could be more profitably grown for fresh pod than for dry seeds.

One hundred seventy accessories were evaluated under shade. Bean yields ranged from 0.02 to 1.58 tons/ha with a mean of 0.42 ton/ha and only 4 yielded higher than 1 ton/ha. A wide variation in plant height was also observed.

D. Peanut

Two hundred fifty seven accessories were screened under shade. Initial results were encouraging especially with one variety (#1) which yielded 3.10 tons/ha.

E. Sorghum

The post-rice cropping trials involving 16 elite varieties and 72 advanced generation lines resulted in four varieties yielding more than 3 tons/ha., namely: CS-104, IS2940, D67-4 and UPLB SG-5. For pre-rice cropping, the problem observed was the longer maturity of sorghum (120 days) which delays the rice crop. Likewise, there are problems in harvesting and theshing as maturity coincides with the heavy rains. Under

shade, there was a substantial reduction in yield especially for the advanced generation lines. Yields ranged from 1.75 to 3.72 tons/ha which are still comparatively lower than yields in the open.

F. Corn

For post-rice paddy planting; 15 sweet, 11 glutinous, 62 flint, and 4 popcorn varieties were evaluated. The yields obtained were comparatively lower than yields under common upland conditions. The highest yielders were Sweet DMR Comp. 31, Glutinous Opaque Com, and Glutinous DMR Comp. 41. Thai Opaque Comp.1, Honduras 70 and Venezuela 1 were also identified as the more promising among the flint and popcorn varieties. Low seed germination due to paddy field conditions was the main problem that affected the performance of most varieties tested.

In the pre-rice cropping trials, green corn was observed to have a bright prospect, although germination has been a consistent problem.

The same varieties as in the lowland trials were screened under shade. The highest yielders were Sweet Corn Popn. 32A (4.310 tons marketable ears/ha.), EG Glutinous 4 (2.495 tons/ha), EG Syn 187, and Dentado Compuesto Branco.

G. Sweet Potato

In the screening after rice, 14 varieties were tested in 1976 and 79 varieties in 1977. For the earlier trials; two entries, C35-1 and BNAS #51 gave respectable yields of more than 10 tons/ha. In the succeeding trials, only 8 varieties gave similar yields.

Fifty-five local introduced and promising varieties were evaluated before rice in 1976. No root yield was obtained during the planting because of too much water. Thus, it was concluded that no sweet potato variety would do well in rice fields before cultivation.

Root yields obtained under partial shade were lower than those obtained after rice. However, the vine yields are comparable to those obtained in the open.

H. Tomato

In 1976, 54 varieties were tested for post-rice planting. Germination varied from 15 to 100%. Twenty entries had 90% germination and above 25 entries yielded more than 1,000 grams per plant. The average yield of 50% of the entries is comparable to, if not higher than the yield of tomato grown in well prepared land. The succeeding test using the 15 highest yielders, however, encountered rat infestation which caused poor seed germination.

Under shade, 5 varieties gave higher fruit setting than in the open, 4 are the same and 14 had higher in the open than under shade during the first trials. In the succeeding trial involving 28 tomato lines, the yield ranged from 0.5 to 1.28 kg/plant with 2 entries yielding more than 1 kg. Yield correlated positively with number of fruits but inversely with fruit size. It was also observed in the succeeding trials that performance of tomato under shade could be affected by the season. In trials coinciding with the rainy season, the performances of most varieties were relatively poor.

I. Eggplant

There was difficulty in obtaining good germination of eggplant in the paddies. It was concluded that eggplant does not perform well under zero tillage after rice.

DEVELOPMENT RESEARCH PROGRAMMES AND ACTIVITIES IN MALAYSIA

Mohamad Yusof Hashim[1/]

Introduction

Since the last National Coordinators Cropping Systems Workshop held in Sri Lanka in December 1977 some changes had been affected in terms of the croppingsystem programmes in Malaysia. The programmes and activities per se have been absorbed within the ambit of the development research programmes.

The primary objective of development or operational research programmes is to undertake location specific (sight related) research activities with the purpose of solving identifiable agro-socio-economic problems of the farmers. The ultimate objective is to develop appropriate farming systems technologies that could easily be adopted by the farming communities thereby helping them to maximize the use of the available resources and gain a higher or better income from their farms.

The projects will be concentrated mainly in the major rice-based - double and single cropping; fully irrigated, partially irrigated, and rainfed - areas which total about one million acres. These areas include such major regional development areas as the MUDA Irrigation Schemes in Kedah, Kemubu Irrigatinon Schemes in Kelantan, Besut Irrigation Scheme in Trengganu, Tanjong Karang Scheme in Selangor and Krian in Perak. Other smaller areas are Sungai Manik, Labu Kubong, Kuala Trengganu, Kuala Brang, Malacca and Negeri Sembilan. The acreages of the rice-based areas are as indicated in Appendix A.

Operational Framework

The Central Rice Research Station at Bumbong Lima and the Field Crop Central Research Station in Serdang serve as the main experimental stations where basic research activities such as breeding, selection, screening, mechanization, fertility, water management, etc. on rice and field crops are conducted.

[1/] Assistant Director Development Research, MARDI.

Outreach research stations located in Kubang Kranji, Alor Star, Tanjong Karang, Parit, and Kuala Trengganu/Kuala Brang serve as development research stations whereby more applied form of research activities including local verification trials of technologies with farmer participation are conducted. Problems or problem areas faced by the farmers within each locality will be identified at these outreach stations. Research programmes and activities will then be developed based on careful analysis of problems and priorities identified at these stations.

At each of these stations there is a complement of research workers of relevant desciplines such as the breeder, the agronomist, the soil scientist, water management scienti crop protection scientist, agricultural engineer, an economist and others when staffs are available and if found to be necessary. In other words there is a multidisciplinary team headed by a station head (team leader) to be responslbe for the activities at each locality.

These research scientists are supported and guided in their work by central stations through constant and direct communications between development and central stations.

The locations of the development stations and that of the central stations are indicated in Appendix B.

Existing Cropping Patterns

More than 65% of the rice-based areas in the country are provided with drainage and irrigation facilities which allow for double cropping. The dominant cropping pattern in the major rice based areas is the rice-rice system. In these areas substantial investment has been incurred in providing drainage and irrigation networks to ensure that the double cropping of rice is implemented most efficiently.

The rice followed by upland crop pattern is practiced mainly in rainfed or partially irrigated areas. This cropping pattern is practiced quite extensively in some parts of Kelantan, Trengganu and to a small extent in Kedah/Perlis and Malacca. Crops planted in the off-season are mainly groundnuts, tobacco, vegetables, and some soyabean.

Types of Research Projects

Basically two types of research projects are undertaken at the development research stations or sites. These are:-

a) Component Technology Research

The component technology research programmes involves implementation of such research programmes as varietal testing, fertility studies, cultural management, and pest

management studies. These are carried out on rented farmers land but implemented by hired laborers or workers and supervised by research workers.

b) Technology Verification

Technology verification involves the testing of package or component technologies on selected farmers lands with farmers themselves participating actively. In these trials agro-economic data are collected. Testings on a number of sites within the locality will provide suffici nt information as to whether the technologies could further be extended to extension agencies. These projects are closely supervised by research workers to ensure that the farmer participants undertake to do the trials according to prescribed directions.

Brief Summary of Research Projects Undertaken in the Main 1978 Season

The types of projects undertaken in the 1978 main season in most of the sites are as follows:-

i) Varietal Improvement Studies

The main purpose of these studies is to evaluate or asses new varieties in terms of their yielding capacity and adaptability to the various environmental conditions existing in the locations. Development of varieties with desirable characteristics such as high yielding, medium to long grain size, good cooking quality, resistance to diseases, and with fairly short maturation period to fit in with the existing cropping patterns is the ultimate objective.

The programmes include progeny ear row selection, family ear row selection, yield trials and adaptability trials. The main lines being tested are the MR series produced at Bumbong Lima using the already released varieties such as SM II, Malaysia or Bahagia as control.

ii) Agronomic Studies

The agronomic studies are aimed at improving cultural or management practices of the rice crop. Such aspects as seedling age, transplanting depth, spacings, planting densities, number of seedlings per hill and fertilizer response, and time and rate of fertilizer application are being studied. The common varieties used for these studies include SM II, Bahagia, Mahsuri, MR7, MR10.

iii) Soil Fertility Studies

Fertility studies have been conducted with the purpose of determining the most efficient combinations on N, P, K for rice in various sites. This also include the economics of fertilizer use on production. The levels of N, P and K combinations vary with the types of soils in the locations.

iv) Crop Protection Studies

The main objective of crop protection studies is to screen various insecticides and fungicides against pests and diseases. Survey of pests and diseases is also carried out to monitor any incidences within the localities. Screening was done mainly against leptocorisa sp, leaf eaters, plant hoppers, rice bug, blast and bacterial leaf blight.

v) Technology Verification Studies

The main objective is to test the agro-economic feasibility of various technologies as components or packages on the farmers field and to monitor any problems encountered before such technologies are passed on to extension agencies. Varieties fertilizer, insecticides, and fungicides are the main inputs provided to the farmers as incentives. The labor is entirely provided by the farm family. Recording and supervision is done by research personnel.

The following gives a brief illustration of the types of research projects implemented according to locations:-

State/Locations	Types of Studies	No. of Sites
Alor Sar/Kedah		
MADA	Varietal improvement	11
Outside MADA	Agronomic studies	2
	Soil fertility	10
	Technology testing	10
Perak		
Parit	Varietal improvement	5
	Fertility	6
	Technology testing	6
Selangor		
Tanjong Karang	Soil fertility	5
Sabak Bernam	Technology testing	10

State/Locations	Types of Studies	No. of Sites
Negeri Sembilan/ Malacca	Varietal Improvement	3
	Fertility	4
	Technology testing	
Trengganu		
Kuala Trengganu	Varietal improvement	8
Besut	Fertility studies	6
Kuala Brang	Crop protection	3
	Technology testing	8
	Cropping pattern studies (soyabean, groundnut, green grams)	2
Kelantan		
KADA	Varietal improvement	6
Outside KADA	Fertility studies	9
	Agronomic studies	2
	Pest and disease control	2
	Technology testing	5
	Field crop	1

Very little work has been done so far on cropping patterns involving rice and other upland crops except for the work at the Kuala Brang site where the field crp branch is experimenting with various relay cropping patterns using rice as the base crop. Possible cropping patterns as indicated below are currently being tested at Kuala Brang.

A. Groundnut - maize 1 rice
B. Sorghum - soyabean - rice
C. Maize - groundnut - rice
D. Soyabean - sorghum - rice
E. Maize - maize - rice
F. Groundnut - groundnut - rice
G. Sorghum - sorghum - rice
H. Soyabean - soyabean - rice

Some work in respect of soyabean and groundnut is also being carried out in Kota Bharu station. However this is confined only to varietal and fertilizer studies. The main problem with the upland crops research is the limited availability of high yielding varieties in the country. Efforts must be devoted to increasing the genetic pool collection and subsequent breeding selection for potential high yielding varieties.

Socio economic surveys have also been conducted in a few areas to gather base line information of the locations or sites. Studies that have been completed include surveys in Krian, Besut and Johol, Negeri Sembilan.

Future Strategies

Efforts in the future will be directed mainly in the strengthening of the research programmes and activities at the identified locations. It is already envisaged that more comprehensive and exhaustive agro-economic and sociological studies will have to be conducted at these locations in the near future in order to ensure that there is a clear understanding of the actual or existing problems faced by the farmers in operating their farms. A more critical analysis of the local problems will definitely have to be undertaken and research activities will then have to be oriented towards solving the identified problems.

Immediately however plans are already on hand to review the various activities and programmes currently being implemented in the sites concerned. Discussions will be held at the sites concerned and all research personnel from the outreach station and those from relevant central stations will be invited. This will be implemented in November 1978 and hopefully by December, the programmes and activities for 1979 will be finalized and compiled for distribution and use.

It is also planned to institute a stronger linkage between the central and development stations to ensure that outreach stations get a strong support in terms of expertise and guidance in carrying out their tasks.

Strong linkages will also be fostered between the institute particularly at the station level and the local extension agencies namely the Department of Agriculture. This will ensure collaboration in terms of ensuring the transfer of new technologies to the farming communities.

Training

The Institute will continue to take advantage of the training programmes offered by IRRI for staffs involved in development research. During 1978 the following have been sent for training at IRRI in Los Banos.

- one for 5 week water management course
- two for the 6 week Genetic Evaluation course
- three for the 6 month Cropping Systems Course

It is expected that the same number as above will be attending the courses in 1979.

Arrangements are also being made to send officers for attachment to various programmes at IRRI by the end of the year or early next year to provide experiences to its research officers in their respective fields.

The institute would also like to take advantage of the opportunity if if there is any for its staff to take courses in agrochimatology at the institute does not have anybody trained in agroclimatology monitoring work.

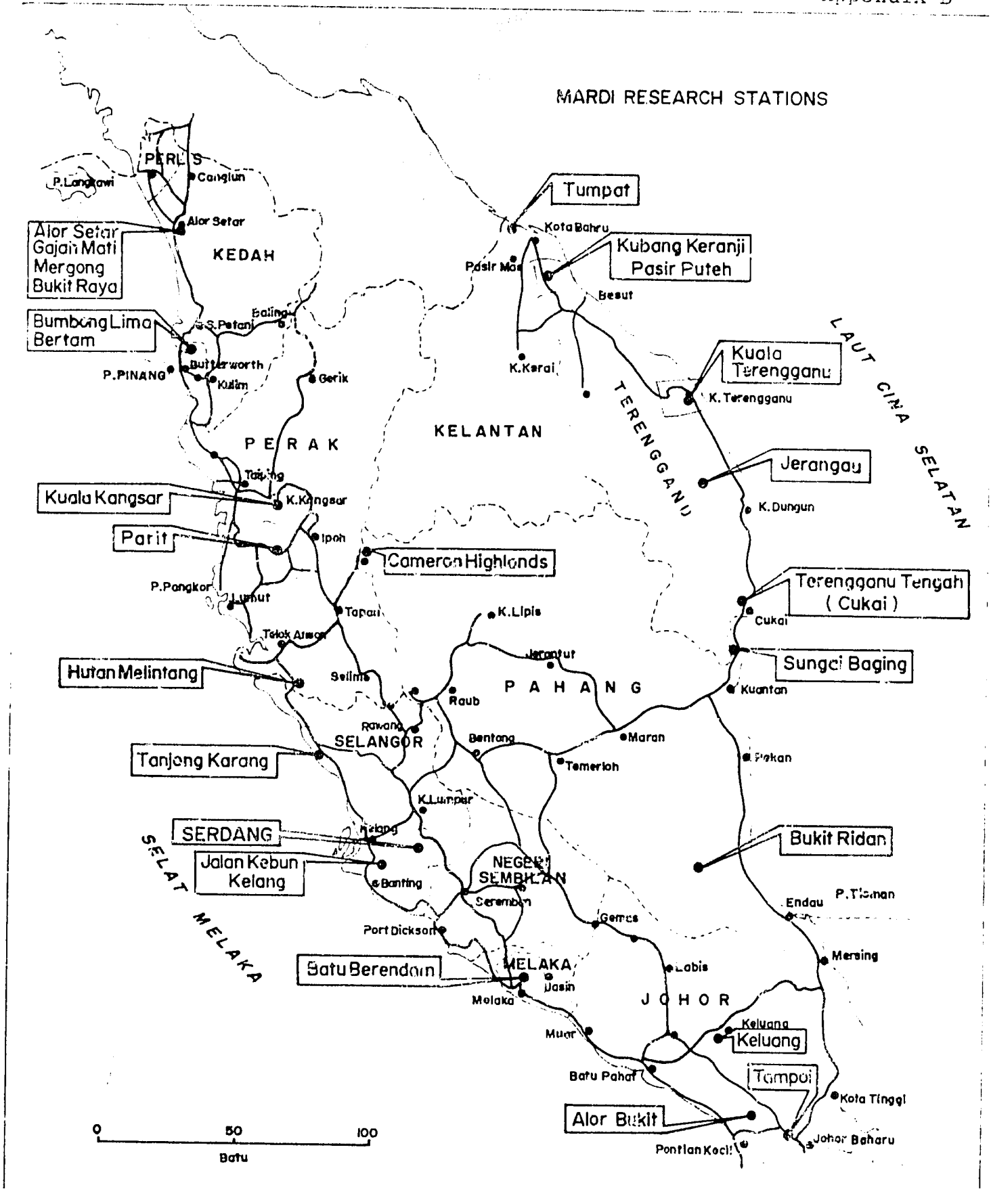
Appendix A

Acreages of principal rice-based areas selected for cropping system research (Economic Branch)[1]

State	Principal Areas	Acreage Irrigated	Acreage Non Irrig.	Research Station
Kedah	Muda	226000	-	Alor Star
	Kubang Pasu	-	8245	
	Padang Terap/K. Star	455	17545	
	Sik	600	6200	
	Kulim/B. Baru	8890	2481	
	Jerai	5217	15660	
	Baling	7658	8662	
		248820	68793	
Perak	Krian	58780	-	Parit
	Sungai Manik and Labu Kubong	21370	-	
	Trans Perak (Bota, Lambor, Kg. Gajah)	10322	1465	
		90472	1465	
Selangor	Tanjung Karang/ Sabak Bernam	51580	-	Tanjung Karang
Negeri Sembilan/ Melaka	Kuala Pilah	8835	4595	Batu Berendam
	Rembau	5461	1678	
	Johol	n.a.	n.a.	
	Jelebu	n.a.	n.a.	
	Melaka Utara	2222	8764	
	Melaka Tengah	9349	14651	
	Melaka Selatan	3200	9228	
		29067	38916	
Trengganu	Besut	10300	5700	Kuala Trengganu
	U. Trengganu	4540	2099	
	K. Trengganu	1000	26639	
		15840	34438	
Kelantan	Kemubu	85541	-	Kubang
	Tumpat Pantai	-	15646	
	Chabang Tongkat	-	25720	
	Gual Periok	-	28727	
		85541	70102	

[1] Economics Branch, 1976. General information and statistics on padi for zonal development under the Third Malaysia Plan, MARDI, Serdang (Mimeographed).

Appendix B


MARDI RESEARCH STATIONS
PERLIS
P.Langkawi
Canglun
Alor Setar
Alor Setar
Gajah Mati
Mergong
Bukit Raya
KEDAH
Bumbong Lima
Bertam
S.Petani
Baling
Butterworth
P.PINANG
Kulim
Gerik
PERAK
Taiping
Kuala Kangsar
K.Kangsar
Parit
Ipoh
Cameron Highlands
P.Pangkor
Lumut
Tapah
Telok Anson
Hutan Melintang
Selima
Rawang
SELANGOR
Tanjong Karang
K.Lumpur
SERDANG
Kelang
Jalan Kebun
Kelang
Banting
SELAT MELAKA
Port Dickson
Batu Berendam
MELAKA
Melaka
Jasin
Muar
Batu Pahat
Alor Bukit
Pontian Kecil
Johor Baharu
Kota Tinggi
Tampoi
Keluang
Keluang
JOHOR
Labis
Gemas
NEGERI SEMBILAN
Seremban
Bentang
Temerloh
Maran
Pekan
Bukit Ridan
Endau
P.Tioman
Mersing
Kuantan
Sungai Baging
Cukai
Terengganu Tengah
(Cukai)
Jerangau
K.Dungun
Kuala Terengganu
K.Terengganu
TERENGGANU
K.Kerai
Besut
Pasir Mas
Kota Bahru
Tumpat
KELANTAN
PAHANG
Raub
Jerantut
K.Lipis
LAUT CINA SELATAN
0
50
100
Batu

REPORT OF CROPPING SYSTEM PROGRAM IN NEPAL

S. N. Lohani and A. H. Manzano[1/]

Introduction

Cropping System Program (CSP) in Nepal was started with the planting of summer season crops in 1977. Initially only two sites viz Parsa and Pokhara were included each with limited number of plots. Results of summer season trials 1977 and detail program was presented during the 6th Working Group Meeting held at Sri Lanka (1). During the winter season 1977/78, work at those sites was expanded. Three more sites viz Rukum, Lalitpur and Sankhuwasabha were added, the trials being mostly of exploratory nature participated by few farmers.

Since early 1978 socio economic studies have also been formally started at all five sites with the joining of economists and anthropologist in the CSP.

The present report will focus on general progress to date and results of winter season 1977/78 on farm trials. Preliminary evaluation of results from adequate number of farms on whole year basis will have to wait till 78/79 winter crops are harvested.

CSP organizational set up and linkage with other programs

At present CSP is one of the component of Integrated Cereal Project (ICP) of Department of Agriculture (DA) with its center in the Agronomy Division. The ICP also includes three major commodity programs on rice, corn and wheat. Programs on barley, fingermillet, legumes, oilseeds and cash crops exist within the Agronomy Division or separately. The latter programs are at various stages of development mostly on the preliminary side. Disciplinewise divisions like Entomology, Pathology, Soil Science etc. exist within the DA. The various commodity and discipline programs are engaged in the development of component technology related to varietal improvement, agronomy, plant protection etc. The potential of cropping system research to develop practical technology through on farm testing is being gradually recognized by various research programs. For example seeds for minikit trials, farmers field trials and large plot pattern trials are obtained from different crop programs to be grown in CSP sites. Meeting and field visits with program chiefs and others are being held from time to time. It is hoped that research activities will focus

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[1/] Program Coordinator and Senior Cropping System Agronomist, Department of Agriculture, Kathmandu, Nepal.

further on farmers field problems and their requirement as these become more obvious through cropping system studies. Experiments on intercropping, relay cropping and multiple cropping are already being started at few experiment stations.

Participation of Regional organization/extension offices (District Agriculture Development Office - DADO) is considered essential not only for extending cropping systems results as a package production program but also during the research phase. For each site concerned, contact with DADO and regional office is maintained which also organize farmers field visit to cropping system sites. Indeed site coordinators and junior technicians are deputed from the DADO. Field assistants are recruited at the site. Also contact with "Panchayat" or local elected organization is being maintained.

The trials are conducted in the farmers field with their full participation i.e. land preparation, seeding and all other operations are carried out by the farmers (seeds, fertilizers and insecticides are provided as incentives). Farmers take part in the choice and discussion of the trial.

Cropping systems work plan and results of 1977/78 winter season trials

When the project is in full swing, the CSP in Nepal aims to have six type of studies in farmers field viz 1) crop cultivation, 2) compost management, 3) bund stabilization and bund fodder production, 4) fodder and firewood tree production, 5) vegetable and fruit distribution, and 6) grazing land improvement. In the subsistence farming, food crops is most important and therefore it is intended to devote at least 80 percent of the work attention to this aspect. The other five studies will be carried out with varying emphasis depending upon the site environment and need. In the winter season 1977/78, experiments were mostly limited to crops at all sites. (Certain activities on vegetable production and compost was also started at four sites.) Trials on crops were of following kinds:

1. Evaluation of cropping pattern alternatives and related studies. Various possible crops suited to different sites and land types were grown to evaluate different cropping patterns. This comprised of several objectives and suitable tests conducted e.g.:

   a. Increase cropping intensity - various possibilities of crop production viz sequence, mixed cropping, intercropping and relay cropping were tested.

   b. Introduction of new crops viz legumes, linseed and barley in some areas.

c. Testing response to fertilizer rates and combinations - such tests were considered important because: 1) fertilizer are costly and scarce in some areas and 2) farmers apply far less than the generally recommended amount based on experiment station trials.

d. Testing management practices viz row seeding, seed rates and weed control.

Studies c and d were often "superimposed" on pattern plots (i.e. under a and b).

2. Conducting "minikit" trials - these trials were received from commodity programs for some crops. The trial consist of 3-4 highly promising varieties (already released or about to be released) to be grown under certain management. Varieties liked by the farmer can be grown in large plots in the coming season.

3. Conducting "farmers field trial" - these trials were received from commodity programs. It had up to 10 varieties. Objective was to evaluate promising varieties in the farmers field condition.

A brief description of site and summary of trial results at four sites are presented below. Details can be examined in CSP Technical reports (2, 3).

Parsa

Parsa district lies in Terai plain (elevation about 60 meter a.m.s.l.). The area comprise mostly of rainfed and irrigated lowland and little upland. Most of the work at this site involves a newly started irrigated region with some trials at rainfed area.

Average (1971-77) annual rainfall is 1420 mm out of which nearly 85 percent fall during June-October (summer crop period). Predominant soil texture in the area is silty loam.

Predominant cropping patterns are rice-wheat, rice-fallow, rice/lentil or linseed relay. Cropping patterns are changing with the availability of irrigation facility. In the irrigated area CSP is testing intensive patterns like rice-wheat-green manure; rice-wheat-rice; rice-wheat-grain legume; rice-potato and peas-grain legume; rice-maize. The nature of trials and results are summarized below.

1. The baseline survey conducted by Irrigation Project operating in the area indicated that only 29.42% of lowland (out of 40,000 hectares in the project area) was planted to wheat after rice, most of the rest remaining fallow. With the newly available irrigation facility wheat can be a profitable crop to follow rice. It also provided opportunity to attain high yield by optimum management of the crop. Farmers in the area were keen to grow wheat. Improved variety RR21 was grown and a series of

superimposed trials were conducted to determine the effects of fertilizer rates and combinations.

Results showed that 60-40-0 was the best among the levels tested, producing 2232 kg/ha. Check plot (without fertilizer) produced 1127 kg/ha. The cost benefit ratio for this treatment was about 1:3.

2. Enquiry of other farmer's management practices on wheat indicate differences in seed rates, fertilizer rates etc. Average yield was 1697 kg/ha.

3. Wheat and chickpea intercropping was tested but found to be unsuitable specially when irrigation can be given. Irrigation damaged chickpea. Seeding method or fertilizer levels were superimposed on different set of trials. Wheat yields from plots with 20-40 and 60-40 NP were 1920 and 2240 kg/ha respectively. Wheat yields from line seeded and broadcast seeded plots were 2185 and 1964 kg/ha respective (both plots received 60-30 NP).

4. Growing of maize in Terai during winter season is feasible and becoming popular among the farmers. Intercropping wheat and maize was suggested to farmers with view to harvest maize for fodder. Fodder shortage occurs during winter. It was also thought that border effects on wheat rows next to skip row would compensate yield loss. Two planting arrangements were superimposed (6 rows of wheat and one row of maize: 6 + 1; 9 rows of wheat and 2 rows of corn: 9 + 2). Wheat grain yields for 6 + 1 and 9 + 2 row treatments were 1845 and 2170 kg/ha respectively. Maize fodder yields for the same were 1008 and 2116 kg/ha respectively. Planting 9 rows of wheat and 2 rows of maize increased yield of both.

5. Yields of lentil obtained in rice-lentil pattern were generally low. Superimposed fertilizer study showed that 20-20-0 NPK gave good response producing 908 kg/ha. Plots with no fertilizer produced 504 kg/ha. The cost benefit ratio for this treatment was about 1:5.

6. Intercropping potato and pea was tested at different fertilizer levels. Pea yields could not be recorded as farmers harvested green pods. Results of superimposed fertilizer study showed that 60-30-30 NPK level was best among the treatments tested producing tuber yield 13.2 m ton/ha. Check plot (0-0-0 NPK) produced 5.2 m. ton/ha.

7. Three new wheat varieties were grown as minikit trials. All the new varieties produced more than check variety RR21: variety UP262 being the topmost yielder.

8. Lentil farmers field trial was grown at Sukchaina (rainfed area). Yields ranged from 260-435 kg/ha. Yields were low possibly due to late planting. However some new varieties appeared better than local check.

9. Superimposed fertilizer study on barley (in rice-barley pattern) did not show any difference in yields between 30-0-0 and 30-20-0 treatments. (Grain yields 1107 and 119 kg/ha). Yields from these treatments were 35

percent higher than check plot receiving no fertilizer. The cost benefit ratio was about 1:1.6.

10. Barley farmers field was grown at Sukchaina. Yields ranged from 766 to 1141 kg/ha showing that none of the new entrees could out-yield the newly released variety HBL56.

Pumdi Bumdi (Kaski District)

Pumdi Bumdi "Panchayat", Kaski district lies in the mid hills. Elevation range from 750 to 1270 meter a.m.s.l. Both upland and lowland exist. Average annual rainfall at nearby area is 4018 mm out of which 85 percent falls during June-October. Major soil type is silty loam.

Predominant cropping pattern in the lowland area rice-fallow; rice-wheat and rice-wheat-maize + beans. A monocrop of rice is grown in about 60 percent of lowland. Predominant cropping patterns in the uplands are: maize+beans-fingermillet (relay)-wheat, maize+beans-mustard; maize+beans-wheat.

Introducing new crops for double cropping in the lowland, testing component technology, intercropping etc. were being carried out in 1977/78 season. Several wheat plots were harvested in haste by the farmers due to dailstorm scare. Hailstorm did not occur however it showed that character like early maturity is very important. Summary of results follows:

1. Wheat variety RR21 was introduced in the area and fertilizer study superimposed in some set of fields. Average yield obtained from pattern plots with 60-0-0 NPK was 1870 kg/ha; average yield from other plots with no fertilizer was 1010 kg/ha. The cost benefit for the fertilizer treated plot was about 1:3. No conclusion could be drawn on superimposed studies as yield samples were taken from few plots only.

2. Intercropping wheat and lentil was tested with superimposed fertilizer study. It showed the advantage of 20-20-0 NPK treatment, giving wheat and lentil yields of 1110 and 600 kg/ha respectively. For 60 kg nitrogen treatment wheat yields did not change but lentil yield was almost reduced by half.

3. In another set of pattern plots mixed cropping wheat and peas appeared promising. Pea yields could not be recorded as farmers picked green pods at different time. Average wheat yield was 1770 kg/ha.

4. Results of barley cultivation showed that it could be one of the potential crop to be grown in paddy fields which are generally left fallow in winter season. Variety Ketch produced 1950 kg/ha.

5. Results of linseed cultivation showed that it could be another crop to follow paddy. Average yield of linseed was 540 kg/ha.

6. Farmers had reported that potato cultivation was often failure due to damage by ant. Potato was introduced as a potential crop in the pattern corn+bean-potato. Soil treatment effectively controlled ants. An average of 12.45 m. ton potato yield was obtained.

7. All the new wheat varieties tested in minikit trials gave lower than RR21.

Lele (Lalitpur District)

Lele Panchayat lies in Lalitpur District close to Kathmandu valley. Elevation is about 1500 meter a.m.s.l.

Average (1971/77) annual rainfall from a nearby location was 2025 mm out of which 86 percent was received in June-October.

Both upland and lowland exist. Lowland soil is clay loam type with good water holding capacity. Upland soil is silty loam to clay loam. Different land types occur within short distance. Double cropping rice and wheat is a common pattern in the lowland. In uplands corn is often grown mixed with soyabeans followed by mustard.

Work at this site was started with winter season crop 1977/78. Intercropping, management studies and introducing new crops were major trial subjects. Summary of results follow:

1. Wheat variety RR21 was grown at recommended fertilizer level under two seeding methods: broadcast and in line. Yields from line sown and broadcast seeded plots were similar giving an average of 2770 kg/ha. The yield obtained with good management was 103 percent higher than average yield in Lalitpur District.

2. Trial on wheat and lentil intercropping (superimposed seeding method) was carried out. Result was not promising as both crop produced low yields. Average yields of wheat and lentil (from broadcast and line seeded plots) were 1200 and 100 kg/ha respectively.

3. Improved barley variety Bonus was introduced as potential crop to be grown in some lowland which is usually left fallow. High yields were obtained; average yield from line seeded and broadcast seeded plots being 3020 and 2480 kg/ha showing that line seeding was better. Results from intercropped plots also showed that line seeding was better.

4. Trial on intercropping barley and lentil was carried out but the combination did not appear promising as lentil yield was reduced considerably. Average yields of barley and lentil (from broadcast and line seeded plots) were 2170 and 110 kg/ha respectively.

5. Lentil was introduced as a possible crop to follow rice. Yield obtained was low and similar for line sowing and broadcast sowing treatments i.e. 447 and 400 kg/ha respectively.

Chauri Jahari (Rukum District)

Chauri Jahari Panchayat lies in Far Western hill district. A hill irrigation scheme was completed in the project area in 1977 covering nearly 600 hectares. Elevation is about 700 meter a.m.s.l.

According to records from irrigation project average rainfall for the period 1975-77 was 1150 mm, 88 percent of which was received during summer crop season (June-September). Predominant soil textures are sandy loam, silty sandy and loam.

Major cropping patterns are upland rice + maize - wheat - fallow or wheat + mustard - fallow; upland rice + maize - lentil - fallow. New cropping patterns proposed for testing are rice (TP) - wheat + mustard - spring maize or moong; fingermillet (TP) - wheat + mustard - spring maize or moong, rice + maize - wheat + legume; maize/finger-millet - barley + legume etc.

Preliminary work at this site was started with winter season crop. This involved cultivation of improved wheat variety RR21 with superimposed fertilizer trials. Also fertilizer trial on local variety of wheat and wheat minikit trials were conducted. Summary of results follow:

1. With no fertilizer treatment wheat variety RR21 produced 2160 kg/ha (average of 15 plots) and local variety produced 1600 kg/ha (average of five plots) showing the superiority of improved variety. Change of variety alone is likely to increase production. The yields were much higher than obtained at other sites.

2. Response of local wheat variety to nitrogen was poor.

3. Response to fertilizer levels of variety RR21 showed that 30-30-0 kg NPK/ha was the best dose producing 4260 kg grain/ha. Compared to untreated check plot the cost benefit ratio for the fertilizer treated plot was about 1:10. Grain yields for 60-0-0 NPK and 60-30-30 NPK were 3090 and 3130 kg/ha respectively. It appeared that potash reduced wheat yield

4. Wheat minikit trial results showed that varieties UP262 and HD1102 gave more than 3 tons/ha.

Training progress and needs

Both degree and non degree training (of various duration and kinds) have been given to people working in the CSP. Training of more people will be needed as the program expands. Cropping systems training and other activities carried out so far are mentioned below:

IRRI Cropping Systems Training (6 months) - Four employees received this training in 1977/78. Out of them three are working as site coordinators. Four more employees have been nominated for 1978/79 training session.

In country CSP training - A fortnight training specially on summer crops and handling of trials was imparted to field assistants working at various CS sites. Similar training on winter season crops will be carried out soon.

Degree training - One employee who got M.Sc. in CS related field in early 1978 has joined the program after return. Two more slots for M.Sc. and one for Ph.D. are already provided (either enrolled this year or will do so by early next year).

Observation trials and workshop meetings - People working in CSP and extension program have participated (8 persons in 1977) in "monitoring tours" organized by Network Coordinator; others have participated in observation tours (within and outside the country) and workshop meetings all of which are useful for enhancing knowledge of cropping system activities at national and international levels. Hopefully such participation will continue in future.

It is realized that specially for production phase large number of farmers, village level workers and others will have to be trained. It is hoped that training mechanism within cropping system will develop in time.

Future research plans

Cropping system research at a site is a fairly continuous process requiring say three years trial results. Both agronomic and socio-economic fit will have to be considered to enable recommendations for target areas. Evaluation of cropping pattern alternatives and related studies of the type outlined earlier will continue. Other work areas will be strengthened.

This being a new program in Nepal; for each site, approval of staff positions recruitment, work familiarity etc. continued throughout the work period - a process not complete yet. Quality of work and results is expected to improve as the required number of people are appointed and their experience also increases. Field monitoring is being strengthened; cost of cultivation data will be available.

Based on experience so far more through matching of crops (and trials) to land type and grouping of trials etc. are intended. Also some research managed trials on of fertilizer response and intercropping are visualized.

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THE FIRST SURVEY IN CROPPING SYSTEM RESEARCH SITES

S.B. Mathema and M.G. Van Der Veen[1/]

Introduction

Quite commonly, a large baseline survey is carried out in cropping systems research. It is generally considered important to conduct a survey of any cropping systems research site in order to develop an understanding of the important features of the area. The surveys include a large range of data which may be used for a number of purposes. However, there are a number of disadvantages to the large survey approach. Survey work can be very expensive as well as time and labor consuming; taking a month or more to carry out and upto a year before results are available. In many cases there is a need to acquire information quickly, in order to make informed decisions regarding the first year's work in cropping pattern trial. Also, resources may not be available to carry out and/or to analyze and write up the results of a large scale survey. Finally, if there is no prior knowledge of the physical social and economical characteristics of the research site, very important problems for study may be missed or inadequately handled in the survey and/or much of the data collected may be of little value or use.

Under examination, it becomes apparent that data for cropping systems research is required for a number of purposes and depending on the purpose, priorities, type of data, accuracy of data and the requirements for the early release of the results may differ. It is also apparent that there are faster, less costly means of a large farm survey.

Economics in data collection may arise if the easiest relevant data to collect is collected first. In this way information needed for decision making can be supplied to the cropping systems program quickly. Further, the information collected initially can also be used to identify, the most important problems or topics requiring additional study.

Later studies to be carried out can be focused on the specific questions identified in the first survey to be important. Each small study can be carried out in a short time and the analysis completed before another study started. In this way the collection of data can be kept under control and balanced against analysis ability and time.[2/]

[1/] Agricultural Economists, Cropping Systems Program, Nepal.

[2/] G. Banta "Economic data collection and analysis for field trials in cropping systems research." Mimeo, Nov. 12, 1977, p.4.

This paper describes the methodology employed by the cropping systems program in Nepal in carrying out the "First Survey" in five cropping systems research sites. The approach followed was to collect and present relevant and useful data about the five sites quickly and economically. This approach may be of interest to those about to carry out a first survey in their cropping systems research.

Sources of data

Information about the cropping systems sites was gathered from three main sources: 1) previous research carried out in nearby areas or in the general area, 2) secondary data from the Department of Statistics, Food and Agricultural Marketing Services Department, Climatological records from Department of Irrigation, Hydrology and Meteorology etc. and 3) key informant surveys.

A considerable amount of agricultural research has already been carried out in the rural areas of Nepal. This work is contained in these development program survey reports which describe the general features of the districts of Nepal, published books, reports by various developmental agencies and studies conducted by governmental organizations etc. The work provides a general understanding of agriculture in Nepal. Some of information provided in these texts was very useful to identify the types of factors which may be important in affecting cropping patterns and in changes in them. This information was used in formulating questions to be asked to the farmers in the key informant surveys.

The relevant secondary data which pretained to the five sites or to the general area of the sites was used to present useful information on such topics as climate, prices etc. More specific information of the social, economical, physical* and climatic characteristics of each site was collected by key informant interviews. By key informant intervies we mean that knowledgeable individuals are used to provide information. In contrast to the respondent to a questionnaire in a farm survey, a key informant does not respond about himself or his own farm but about the situation in the general area. In this way only a few individuals need to be interviewed in order to get information concerning the whole site. However, the type of data which can be reliably and accurately collected by key informat surveys is limited to that which concerns the community as a whole on directly observable phenomena and which requires little evaluation or inference by the informants.**

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* The soil characteristics were also surveyed by member of the cropping systems staff and were measured by soil analysis.

** John J. Poggie Jr. "Toward Quality Control in Key Informant Data" Human Organization Vol. 31, No. 1 Spring 1972.

Cropping systems research in Nepal is being carried out in governmental units called Panchayats and the head of the panchayat is called the Pradhan Panch. Each panchayat contains about 1,000 families and is divided into 9 wards.

In the key informant survey, two knowledgeable farmers were interviewed from each ward where cropping systems research is being carried out. The farmers were asked about the situation in their own wards and the answers of the two farmers interviewed from each ward were compared to assess reliability. Requestioning was carried out, if needed, where descrepancies occurred in the answers given. The Pradhan Panchs were also interviewed about their Panchayats and they were generally able to rely on secondary data available to them on topics such as the population, household number, land area etc. existing in each ward in the panchayat. Merchants and employees of credit and input supply institutions were also interviewed.

Overall, an average of 12 farmers and one Pradhan Panch were interviewed at each site and the time spent collecting data at each site was generally less than one week.

Data collected

Following is a partial listing of the data collected in the survey. The data collected in the first surveys at other sites and in other countries could differ depending upon the research already carried out, the secondary data available, and the topics considered to be important in cropping systems.

Data	Source*
Physical characteristics	
1. Soil type and characteristics	Observation, Soil Soil Samples
2. Monthly rainfall and temperature data for five years	S.D.
3. Months freezing occurs	P.P.I.
4. Occurance-timing of hail damage last five years	P.P.I.
5. Topography	Observation
6. Map of the Panchayat	Hand drawing (Sketch)

*
K.I.S. - Key Informant Survey (farmer)
P.P.I. - Pradhan Panch Interview
S.D. - Secondary Data

Data	Source
Common information	
1. Location of nearest permanent markets	P.P.I.
2. Location of nearest temporary markets	P.P.I.
3. Nearest source of chemical fertilizer and prices	P.P.I.
4. Nearest source of other farm inputs and prices	P.P.I.
5. Prices for agricultural products last year	P.P.I., merchants, S.D.
6. Credit sources	P.P.I., credit institution
General information by ward	
1. Amount of land by land type	P.P.I., S.D.
2. Household number	P.P.I., S.D.
3. Population by sex over and below 14 years old	P.P.I., S.D.
4. Household number by caste	P.P.I.
5. Household number by religion	P.P.I.
6. Language generally spoken	P.P.I.
7. Number with army experience	P.P.I.
8. Location (and attendance) of schools	P.P.I.
9. Location of health care	P.P.I.
10. Sources of water	P.P.I.
Crop production and use	
1. Cropping patterns by land type, percent of area devoted to each pattern, planting and harvesting dates	K.I.S.
2. Varieties planted, average yield per variety, fertilizer use.	K.I.S.
3. Percent of each crop produced which is sold and average price	K.I.S.
4. Uses of the crop residues	K.I.S.

Data	Source
5. Changes in cropping patterns last 5 years	K.I.S.
6. Differences in cropping patterns between large and small farms	K.I.S.
7. Production practices generally followed for each crop	K.I.S.
Fallow fields	
1. Amount and timing of fallow fields by land type	K.I.S.
2. Main reasons for leaving the land fallow	K.I.S.
3. Attitude about tilling the fallow land in the future	K.I.S.
Farm size	
1. Size distribution of land holdings	K.I.S.
2. Mix of land type by land holding size incidence of leased in land by land holding size	K.I.S.
Livestock	
1. Disbribution of the number of livestock owned per household by type of livestock	K.I.S.
2. Common livestock feed, summer and winter, by type of livestock	K.I.S.
3. Periods of the year when finding feed for the livestock are most critical	K.I.S.
4. Common compost making practices	K.I.S.
Labor	
1. Busiest times of the year and activities	K.I.S.
2. Most slack times of the year and activities	K.I.S.
3. Times when it is difficult to hire labor	K.I.S.
4. Exchange labor practices	K.I.S.
5. Labor hired number, tasks, days, wages by sex	K.I.S.

Data	Source
6. Off-farm employment, type, number, timing	K.I.S.
7. Time and timing devoted to collecting fire-wood	K.I.S.
Level of subsistence	
1. Number of farms too small to provide enough food for the household's needs in a normal year	K.I.S.
2. Number of farms larger than in needed to provide the food needs of a household	K.I.S.
Fruit Trees	
1. Number and type of fruit trees grown	K.I.S.

Limitations

The basic objective of this kind of study is to understand the existing farming systems and the area as a whole in general. It describes in a general way the main cropping patterns followed by the farmers and analyzes components of the farming system and how they could affect cropping systems. This kind of study helps to identify subjects or problems requiring additional research. However, the topics covered are limited to some extent and the accuracy of some of the data (especially on crop yields, farm sizes etc.) will probably be improved in the future, as more research in the field is carried out.

RESEARCH ON CROPPING SYSTEMS IN INDIA

K.R. Kulkarni, K.S. Krishnan & S.B. Hukkeri[1/]

Two important crop seasons in India are the Kharif and rabi. The karif season normally starts with sowing from June-July with the onset of sout-west monsoon. The crop may be harvested in November-December. The rabi season may start with north-east monsoon rains in October and harvest follows in February-March. Where irrigation facilities are available, a summer crop is taken by sowing in January-February and harvesting in May. Sometimes rabi and summer may not be sharply marked and in many instances the second season is referred to as rabi/summer or rabi season.

The temperatures in kharif season are fairly high ranging from 20-30 degree centrigrade considered optimum for crop growth. Except the north western portion and some parts of the south, the moisture index (P-PE/PE x 100) for most part of the country is slightly moist to extremely wet. The variation in moisture index and availability of irrigation facilities determine the cropping pattern in kharif.

The temperature conditions during rabi are generally low from 10-20 degree C except in the southern coastal districts where the temperatures are fairly high, 20-28 degree C, and northern most portion of Punjab, Jammu and Kashmir touching up to 0 degree C. The crops during rabi mature mostly on stored moisture in the soil, as they grow for most part during non-rainy months. Timely, assured and adequate irrigation facilities play an important role in deciding the productivity of crops in rabi.

Cropping systems

Land resources being limited, emphasis has to be placed on increasing the productivity per unit area. Temperatures and climatic conditions being favorable throughout the year over most part of the country, it is possible to grow more than one crop in a year provided water is available.

1/ Project Coordinator (Agronomy), All India Coordinated Agronomic Research Project, U.A.S., Bangalore; Senior Scientist and Head, Crop Sciences, Department, I.A.S.R.I., New Delhi; and Asst. Director General (Agronomy), I.C.A.R., Krishi Bhavan, New Delhi.

At present, 22% of the net sown area is irrigated and it is estimated that the irrigation potential could be developed up to 42%. In some parts of the country, spread of rainy season is long enough to provide ample scope for double cropping.

The cropping system depend primarily on soil and climatic factors but as they evolve, also represent integrated effect of requirements, local habits and economic factors through time. Technological innovations have profound effect on cropping systems.

Considering the land use pattern in the country, about 45 to 46% of the reported area (305.6 mi ha) is sown with crops. The remaining land is utilized under forests (21.5%), fallow land (7.0%), other uncultivated area (10.9%) and area not available for cultivation (15.0%). The cropping intensity is 117.7 and the net sown area is 141.2 million hectares (1972).

About 75% of the net sown area is cropped with food crops, of which 61% is under cereals and 14% under legumes. Rice (22.3%), wheat (10.8%) and sorghum (10.2%) are the important cereal crops while bengal gram (4.7%) is the important pulse crop. Among the oil seed crops (8.8%), groundnut occupies the largest area (4.5%). Cotton occupies about 4.7% area. The states that grow a large proportion of their net sown area under principal crops are shown in Table 1.

The efficient areas and the extent of spread of important crops has been discussed by Kanwar (1968), considering the yield index and relative spread.

$$\text{Yield index} = \frac{\text{Mean yield of districts or groups of districts}}{\text{Mean all India average}} \times 100$$

$$\text{Relative spread index} = \frac{\text{Area expressed as percentage cultivated area in a zone}}{\text{Area of the crop expressed as percentage total area in the country.}} \times 100$$

High spread = 90 to 200%

Low spread = 30 to 90%

High yield = 60 to 200%

Low yield = 30 to 60%

Rice

High yield and high spread areas have either heavy rainfall or abundant supply of irrigation water with warm temperature during growth period. In high yield and low spread areas, rice cultivation is increasing under irrigation. From the point of economy in water use, rice is to be recommended for low lying water logged, saline and alkaline lands, in heavy moisture retentive soils, with low porosity and only during rainy months with rainfall above 30 cm/month. The low yield areas have generally marginal land for rice, low moisture, inadequate rainfall and inadequate irrigation facilities.

These areas are more suitable for crops like, 1) Jowar in black soil, 2) Bajra on grey brown or alluvial soil, 3) groundnut on red soil, 4) maize on well drained soils. The important crops sequences depending upon availability of water are:

1. Rice-rice
2. Rice-wheat
3. Rice-groundnut
4. Rice-cotton

Wheat

The most efficient zone (high yield and high spread) is the alluvial soil tract of Punjab, Haryana, western U.P. and Rajastnan. Mean temperature range of 10 to 20 degree C with moisture index of 60 to 80% is the best. In the high yield and low spread areas, the main limitation is adequate irrigation source. In low yield and high spread areas, the crops is mostly grown under rainfed condition and the yield can be improved by better agronomic practices. Wheat generally follows a kharif crop in irrigated/assured rainfall areas. In dry areas, the crop is grown on stored moisture in soils that are fallow in kharif.

Cotton

High yield and high spread areas occur in South West Punjab, Haryana, Rajasthan, part of north Gujarat and some districts in Tamilnadu, Karnataka and Andhra Pradesh. These areas are most suited for long staple cotton and produce 70% of the long staple cotton in the country. In high yield and low spread areas, irrigation is the most limiting resource. Low yield and high spread areas produce short staple cotton under rainfed condition. These areas could be diverted to production of jowar, bajra and groundnut according to soil and climate. Cotton in irrigated areas is sown in wide spaced rows of 75 to 100 cm. The crop needs 2½ to 3 months to cover the land fully. It is possible to grow short duration crops earlier to sowing of cotton or plant cotton in the standing kharif crop.

Sorghum (Jowar)

The most efficient region is the peninsular, central and southern states, in black soils which have high moisture retentivity. Vast areas are rainfed. Jowar can be substituted with groundnut in some areas. With introduction of high yielding varieties, jowar-wheat is becoming an important crop system under irrigation.

Pearl-millet (Bajra)

Punjab, Haryana, Uttar Pradesh, Rajasthan, parts of Gujarath, Andhra Pradesh, Manarashtra and Timilnadu are the most efficient areas for Bajra. It is difficult to replace this crop particularly in low rainfall areas. Under irrigation Bajra-wheat rotation is quite common.

Groundnut

Areas of high production for this crop are parts of Tamilnadu, Andhra Pradesh and Maharashtra. Groundnut under irrigation is also becoming quite common, as groundnut-wheat or rice-groundnut rotations.

Maize

The most efficient maize belt is the submountaneous tract of northern India and parts of Rajasthan and Bihar. In south also, this is a good crop to replace dry paddy in low rainfall areas under well drained soils in transition belts and under irrigation. Maize-wheat is the common rotation under irrigation.

Sugarcane

Yields in the northern states are low (Sugar 3.29 to 3.69 tons/ha). More growing period, more use of fertilizers and irrigation are the reasons for high yield in south. Sugarcane is planted in rows of 90 to 120 cm apart. The crop grows slow for about 3 months before it can cover ground. It is possible to grow inter-crops with adequate fertilizer without affecting the yield. (Compared to south 7.7 to 17.63 t/ha).

The All India Coordinated Agronomic Research Project

This is the oldest coordinated research project of ICAR. The work was started as early as in 1956. Under this project the experiments are conducted at 42 agronomic research centres and 52 experiments on cultivators' field districts. The project has main emphasis on evolving suitable agronomic techniques for cropping system rather than individual

crops. The centres and districts are distributed in different agro-climatic and soils regions of the country.

I. Production potential of crop sequences at Agronomic Research Centres

The experiments on production potential of crop sequences in different agro-climatic regions of the country were started during 1969-70. Chokhey Singh et. al (1977) presented the average productivity at some of the promising centres. In all, 37 research centres were involved in conducting these experiments. Out of these, the productivity of more than 10 tons grain yield/ha per year was achieved at most of the centres except 4 in the north zone, 7 in the central zone, 2 in the eastern zone and one in the southern zone. The major constraint for attaining the high productivity was irrigation water at these centres. Based on the performance of crop sequences during different years, the promising sequences have been listed in Table 2. Out of 60 promising crop sequences identified for various regions, 25 are with rice crop. Some of the sequences involving pulses, vegetables and forage crops have also been listed. Detailed crop production technology for these crop sequences at the respective centres is being worked out to demonstrate the findings on the fields of cultivators.

II. Studies on economy in fertilizer use through farm yard manure (F.Y.M) in selected crop sequences

It is essential to utilize the available F.Y.M. to the best advantage in a crop sequence along with fertilizer for obtaining good crop yields. With this view, experiments were conducted on the fields of cultivators in selected crop rotations.

1. Rice-rice rotation. The data obtained for 3 years in mixed, red and black (Tirunelveli district) red sandy (Mysore district) and red loamy (Puri district) soils are presented in Table (3.1 to 3.4).

The average response to application of 12 tons FYM/ha was 9.1 q/ha of which the direct response in kharif was 6.6 q and residual response was 2.5 q/ha. The responses were high particularly in red sandy (12.9 q/ha) and red loamy soils (11.1 q/ha). The response to application of 60 kg P_2O_5 over N_{60} during rabi season was high in Tirunelveli (6.6 q/ha) and Mysore (9.3 q/ha) whereas the response was low in Puri district (1.8 q/ha). The response to application of 60 kg K_2O/ha to kharif rice was high in the red sandy soil of Mysore district (7.5 q/ha). Application of potash in kharif had no residual effect on rabi crop. The yield levels of plots receiving 12 tons FYM + 60 kg N/ha in kharif and 60 kg N/ha in rabi were on par with F_0N_{120} in kharif and F_0N_{60} in rabi, indicating that 60 kg N/ha could be saved by application of 12 tons FYM/ha. However, for attaining high productivity, application of balanced fertilizer in the form of NPK in kharif was found essential (11.7 tons/ha). Only moderate yields could be achieved by application of 12 tons FYM + 60 kg N/ha in kharif and 60 kg N/ha in rabi (10.5 tons/ha) as compared to no fertilizer treatments giving an average yield of 8.0 tons/ha.

2. Rice-wheat rotation. The experiments were conducted in the districts of Bhagalpur and Manipur with alluvial red and yellow soils respectively (Table 3.2). The responses to 12 tons FYM/ha was 11 q grain yield/ha in Bhagalpur and 12.7 q/ha in Manipur. FYM applied in kharif did not show conspicuous residual effect on the yield of rabi crop. Application of 60 kg P_2O_5 over N_{60} to rabi crop receiving 12 tons FYM/ha in kharif produced about 5.1 q/ha additional grain in Bhagalpur and 4.0 q/ha additional grain yield in Manipur. Application of 12 tons FYM + 90 kg N/ha to kharif and 60 kg N/ha to rabi crop produced practically the same total yield (7.4 tons/ha) as that of $N_{120}P_{60}K_{60}$ in kharif + N_{60} in rabi (7.6 tons/ha). The difference of 2 q/ha was in kharif crop. The beneficial effect of NPK application over FYM+N alone was observed only on the rice crop in the alluvial soil of Bhagalpur district whereas no such effect was observed in red and yellow soil of Manipur district. The results have thus brought out that there is good scope to save the fertilizer and obtain moderately high yields by application of FYM in judicious combination with nitrogen fertilizer.

3. Maize-wheat rotation. The experiments were conducted in alluvial soil of Bulandshar district and brown hill soil of Kangra district (Table 3.3). On an average, maize yields were low in Bulandshar while the wheat yields were low in Kangra district. Application of 12 tons FYM produced 2.9 q/ha additional yield of maize in Bulandshar while the response was 8.2 q/ha in Kangra district over no FYM and no nitrogen. The residual response with FYM in wheat crop was however high in Bulandshar (5.6 q/ha) compared to Kangra (3.6 q/ha). On an average application of 12 tons FYM and 90 kg N/ha to maize and 60 kg N/ha to wheat (6.1 tons/ha) was as good as applying $N_{120}P_{60}K_{60}$ for maize and N_{60} for wheat (6.1 tons/ha). These results also have brought out the possibility of reducing the fertilizer use by application of FYM in maize-wheat rotation for obtaining moderate yields.

4. Sorghum-wheat rotation. The data of Chitredurga district with mixed red and black soil is presented (Table 3.3). The yield levels of the crops were in general low. Application of 12 tons FYM to sorghum produced a direct response to 6.6 q grain yield/ha and had practically no residual effect on wheat crop. The response to 60 kg P_2O_5 over N_{120} in kharif was high being 5.7 q/ha. Similarly, response to 60 kg P_2O_5 over N_{60} during rabi was conspicuous (5.1 q/ha). The response to potash application at 60 kg K_2O/ha over $N_{120}P_{60}$ was also observed in kharif crop (5.3 q/ha). Application of 12 tons FYM + 90 kg N/ha to kharif and 60 kg N to rabi crop produced almost the same total yield (4.3 tons/ha) as $N_{120}P_{60}$ to kharif and N_{60} to rabi (4.2 t/ha). However, for obtaining the highest yield, $N_{120}P_{60}K_{60}$ in kharif and N_{60} in rabi was found to be essential (4.9 tons/ha).

5. Pearl millet-wheat rotation. The data from Gurgaon district in the alluvial soil and Jind district with calcarious sierozem soil are presented (Table 3.4). The yields of pearl millet crop were low in both

the districts while the yield of wheat was low in Gurgaon and satisfactory in Jind district. Application of 12 tons FYM to pearl millet produced a response of 3.4 q/ha and a residual response to 5.0 q/ha on wheat in Gurgaon while the corresponding responses in Jind district were 4.2 and 4.1 q/ha respectively. Application of 60 kg P_2O_5 over 120 kg N/ha to pearl millet crop produced an average response of 2.7 q/ha in Gurgaon and 3.0 q/ha in Jind while application of 60 kg K_2O over $N_{120}P_{60}$ did not produce substantially higher yields. Application of 12 tons FYM to pearl millet with $N_{60}P_{60}$ to wheat produced practically the same total yield (15.2 t/ha) as $N_{120}P_{60}K_{60}$ to bajra and N_{60} to wheat (5.2 t/ha). Almost the same yield was obtained by the application of 12 tons FYM and 90 kg N/ha to pearl millet and 60 kg N/ha to wheat crop (5.1 tons/ha). These results also clearly bring but the possibility of considerable economy in fertilizer use by use of FYM while aiming at moderate yield levels.

III. Studies on fertilizer management in crop sequences

Under conditions of limiting fertilizer availability, it is essential to determine the dose and also the type of nutrient to be applied to the crops in a sequence. With this view, experiments were conducted in selected crop sequences in different districts (Table 4.1 to 4.5).

1. Rice-rice rotation. In all, 418 experiments were conducted and the total average yield of plots receiving no fertilizer was 60.1 q/ha (Table 4.1). The highest average response of 37 q/ha was obtained by application of recommended level ($N_{120}P_{60}K_{60}$ kg/ha) to both the crops. The total response to recommended fertilizer application were particularly high in red sandy soil of Mysore (59.4 q/ha), red loamy soil of Balasur (59.4 q/ha), coastal alluvial soil of Pondicherry (48.5 q/ha). By reducing the fertilizer dose to 75% in kharif, there was an average reduction in total yield of 4.8 q/ha. With reduction in fertilizer, the yield was reduced drastically in red sandy soil of Mysore (12.1 q/ha), red loamy soil of Balasur (9.4 q/ha). The total response was reduced progressively with a reduction in fertilizer dose. With 50% recommended fertilizer to both the crops ($N_{60}P_{30}K_{30}$ kg/ha), the average response was 22.4 q/ha. The results have thus indicated that for rice-rice rotation, application of fertilizer at recommended level is essential to obtain high crop responses. The crop responses are more in soils with lesser fertility status compared to soils with better fertility status. Response is also dependent upon the rainfall occuring in the districts. In general, high rainfall areas have shown lesser response to fertilizer application compared to the low rainfall irrigated areas.

2. Rice-wheat rotation. In all, 285 experiments were conducted and the average total yield of plots receiving no fertilizer was 35.4 q/ha (Table 4.2). The average highest total response of 46.6 q/ha was obtained by applying a fertilizer dose of $N_{120}P_{60}K_{60}$ kg/ha to both the crops. High response to fertilizer application was obtained in the alluvial soils of Fatehpur (51.5 q/ha), Saran (50.5 q/ha) and mixed red and black soil of

Banda district (53.0 q/ha). Rather low responses were obtained in the alluvial soil district. Delhi (27.1 q/ha) and laterite soil of Midhapur (29.4 q/ha). Reducing the fertilizer dose to 75% of recommendation to kharif crop resulted in a reduction of 5.8 quintal total yield, of which 4.4 quintal was in kharif and 1.4 quintal was in rabi. The response to fertilizer application decrease progressively with a decrease in fertilizer dose. With half the recommended fertilizer dose of $N_{60}P_{30}K_{30}$ kg/ha to both the crops, the average total response was 28.3 q/ha. The results have thus indicated that for obtaining high response, application of fertilizer at recommended level is essential for both the crops.

3. Maize-wheat rotation. In all, 198 experiments were conducted and the data are presented in Table 4.3. The total yield of the crop sequence receiving no fertilizer was 36.8 q/ha. The yield levels were higher in submountaneous soil of Una (43.5 q/ha). The highest response of 44.9 q/ha was obtained by application of $N_{120}P_{60}K_{60}$ kg/ha to both the crops in the rotation. The responses were high particularly in the alluvial soil of Bulandshar (55.9 q/ha) and low in Saran district (37.8 q/ha). Reducing the fertilizer dose by 75% to the kharif crop in the sequence resulted in the average loss of 4.9 quintal production/ha. The reduction in yield was mainly in maize. The response to fertilizer reduced progressively with reduction in fertilizer dose. With 50% fertilizer application ($N_{60}P_{30}K_{30}$ kg/ha) to both the crops, the average response was 27.3 q/ha. It is observed that the plots receiving phosphate, whether in kharif or rabi have yielded more than plots receiving N and K only, which indicates the importance of phosphorous application. The results have thus brought out that application of recommended fertilizer dose to both the crops in balanced proportion is essential for obtaining high crop responses.

4. Sorghum-wheat rotation. In all, 104 experiments were conducted and the data are presented in Table 4.4. The total average yield of crop sequence was 29.7 q/ha. The sorghum yields were better in the districts of Chitradurga, Dhulia and Usmanabad while the wheat yields were better in Dhulia district. The crop responses to fertilizer application were in general low in the district of Chatrapur. Highest total response of 43 q/ha was obtained by application of $N_{120}P_{60}K_{60}$ kg/ha to both the crops. With 75% reduction in fertilizer to kharif crop, there was an average loss in yield of 6.1 q/ha in kharif and had practically no effect on the yield of rabi crop. The results also brought out that NP applied plots produced better response compared to NK applied plots during both the seasons. The crop response decreased progressively with reduction in fertilizer dose. With 50% fertilizer to both the crops ($N_{60}P_{30}K_{30}$/ha), the total response was only 24.0 q/ha. These results have brought out the importance of recommended fertilizer application for sorghum-wheat rotation.

5. Pearl millet-wheat rotation. There were 230 experiments and the yield data are presented in Table 4.5. The average yield of pearl millet and wheat crops in control plots were 10.7 and 18.9 q/ha amounting to total of 29.6 q/ha. The pearl millet yields were low in the alluvial soil

of Gurgaon, red and yellow soil of Ajmer, medium black soil of Kaira and red sandy soil of Bellary. Wheat yields were low in red sandy soil of Bellary in South and high in alluvial soils of Delhi, calcarious seirozem soil of Jind district in the north. The average response to application of $N_{120}P_{60}K_{60}$ kg/ha to both the crops was 34.0 q/ha. Reducing the fertilizerdose to 75% for the kharif crop resulted in reduction of 2.7 q yield/ha in pearl millet and 0.9 q yield/ha in wheat, the total response being 30.4 q/ha. NP applied plots produced higher yield over NK applied plots in both the seasons. However, considering the total productivity of the sequence there was no much difference. With 50% recommended fertilizer dose to both the crops, the mean response was 19.8 q/ha. These results have brought out the importance of recommended fertilizer application to both the crops in the sequence for attaining high levels of productivity.

IV. Studies on intercropping in wide spaced row crops

Wide spaced crops like sugarcane, cotton and red gram have slow growth habit in early stages and they take about 2½-3 months for covering the ground fully. It is possible to utilize the available space by intercropping with suitable crops which have short duration and differential growth habit compared to the main crop. Results of some of the experiments with intercropping are presented below:

(a) Intercropping in cotton. The results of experiments on intercropping in cotton are presented in Table 5. At the Agronomic Research Centre Akola, green gram and cowpea were tried as intercrops in cotton, with and without graded levels of fertilizers for the intercrops. The yield of main crop was not affected significantly due to intercropping and on the contrary the yields were slightly improved during both the years of experimentation. The index of gross return was 40-60 higher in intercropping with green gram and 40-70% higher in intercropping with cowpea.

Similarly, encouraging results were obtained by intercropping of onion in Hampi cotton at Siruguppa. The yield of main crop of cotton was affected by intercropping with cowpea or 4 rows of onion but it was not affected when only 2 rows of onion were planted. In this experiment, onion was planted about a month earlier in paired rows of 25 cms., leaving a gap of 50 cms and the cotton crop was dibbled later. Onion and cotton intercropping has been found to produce higher gross return (Rs. 4886/ha) compared to growing cotton alone (Rs. 3891/ha). These results have been demonstrated on larger areas on the fields of cultivators.

(b) Intercropping in sugarcane. Sugarcane was planted at recommended row spacing of 90 cms and paired rows of 60 cms with a gap of 120 cms. between the paired rows. Crops like radish, wheat, cowpea and lady's finger were grown as intercrops in different row proportions as shown in Table 6.

The results indicated that the yield of sugarcane was not affected by planting in paired rows. None of the intercrops affected the yield of main crop conspicuously except radish, when grown in 5 rows in normal planting and onion when grown in 7 rows in paired row planting. These caused yield reduction of about 8 t/ha. Considering the gross returns, sugarcane in paired row planting + radish (Rs. 22,531/ha) and sugarcane in normal planting + onion (Rs. 19,631/ha) were found to be beneficial compared to sugarcane alone (Rs. 15,694 and 14,364 respectively). The yield of wheat was also satisfactory without affecting the sugarcane yield in the normal planting. The results thus indicate that it is possible to take the intercrops which do not grow tall and overtake the main crop. However, higher levels of additional fertilizer application may be needed to maintain the yield of sugarcane.

V. Choice of crops and cropping systems in rainfed areas

Kharif and rabi are the two important seasons. Selection of suitable crop is dependent upon the type of soil and rainfall pattern. A number of crops were tried at selected research stations. Data are presented in Table 7.

1. Talab Tillo (Jammu). The station receives an annual rainfall of about 1150 mm of which about 850 mm are received between June to September. Months of January to March receive rainfall between 5 to 7 cm each. The soil type is alluvial.

Maize was found to be the best crop in kharif while for rabi season the crops of wheat, safflower, barley and mustard were found to be good. Maize-wheat and maize-safflower rotation were found to be good double cropping sequences.

2. Sehore (Madhya Pradesh). The station receives an annual rainfall of 1209 mm of which about 1105 mm are received from June to September. The soil type is deep black. Because of moisture retentive soils, both kharif and rabi crops are possible. For kharif season, sorghum and blackgram are the promising crops. Wheat is a good rabi crop. Bengalgram, sunflower and safflower are the other promising rabi crops.

3. Junagadh (Gujarat). The station receives an annual rainfall of 743 mm of which about 628 mm is received between June to September. Soils are medium black. Sorghum, pearl millet, groundnut, castor and soybean are the promising crops in kharif. Out of these, groundnut, castor and soybean are found to be more remunerative but sorghum and pearl millet are important staple food crops for human and cattle consumption.

4. Chiplima (Orissa). The station receives good annual rainfall of about 1660 mm of which about 1546 mm is received from June to October. Soils are red and yellow. Blackgram, Deccan hemp, groundnut, rice finger millet and maize are the promising crops from the point of yields and cash returns. Horsegram appears to be the only promising crop for rabi season. Next in order in green gram.

5. Akola (Maharashtra). The station receives an average rainfall of 827 mm which is distributed mostly from June to October (801 mm). Medium black soils occur at this station. Hybrid sorghum followed by safflower, hybrid sorghum-bengalgram, greengram followed by safflower are the promising and remunerative double cropping systems for this centre.

6. Hagari (Karnataka). The station receives 518 mm annual rainfall. May, August, September and October are the months that receive more than 5 cm rainfall each, amounting to a total of 359 mm. The station has deep black soil. Safflower, sunflower and rabi sorghum are the important crops. Though the oil seed crops are more remunerative, sorghum is the staple food crops for human and cattle consumption.

Future Line of Work

1. In irrigated areas, it is essential to study the varietal adjustment of crops (long, medium or short duration) in kharif and rabi seasons to find out the pattern for attaining high production.

2. Generally the irrigation water is adequately available for a kharif crop. Under conditions of limiting water supplies during rabi, it is essential to find out the most suitable crop so as to get high total yields and returns.

3. Studies on intercropping in wide spaced row crops need to be intensified to make fuller use of available land resources. Intercropping in the plantation crops to utilize the cubical volume of space is a specialized aspect of such study.

4. Crop management practices such as tillage, manure, fertilizer use, pest control etc need to be studied in more depth for different cropping systems. In the areas with extended rainfall without irrigation facilities, systems of double cropping by selecting short duration crops or a short duration catch crop followed by a regular crop or a regular crop with relay planting of second crop are to be developed.

5. More studies need to be conducted on crop substitution in rainfed areas to find out the most suitable crop for a given soil, quantum and period of rainfall and date of sowing. In scarcity rainfall areas, mixed and intercropping practices to enhance overall productivity of land and reduce the risk of total crop failures, need to be developed. Fertilizer requirement of inter and mixed cropping systems need to be studied in greater depth.

6. Cropping pattern for different sizes of holdings to achieve high production, net return and employment need to be developed. Mixed farming practices such as dairy, poultry, sericulture etc need to be developed along with cropping systems to make small holdings economically viable and remunerative.

7. With a given set of resources alternate cropping systems need to be developed leaving choice to the farmer, consistent with his requirement and skills.

Work on these aspects is in progress under the research programme of some of the Coordinated Research Projects, I.C.A.R. Institutions and Agricultural Universities. The efforts need to be intensified.

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ABSTRACT

Two important cropping seasons in India are kharif and rabi. The temperatures in kharif are fairly high and the moisture index varies from slightly moist to extremely wet, in most parts of the country. The temperatures during rabi are fairly low except in the coastal belts of south and extremely low in the northern most part of the country. The rabi crops mature mostly on stored moisture in the soil, as they grow for most part during non-rainy months. With irrigation facilities, crop production is also undertaken in summer months.

About 45-46% of the reported area in the country is cultivated. Out of this, 75% is sown with food crops, of which 61% comes under cereals and 14% under pulses. Rice, wheat and sorghum are important cereal crops and Bengalgram is the important pulse. Among oil seeds, groundnut occupies large area. Cotton is the important fibre crop. Cropping intensity is around 1.18.

The crops are distributed according to climate and soil type in different parts of the country. With irrigation or extended rainfall resources, double cropping and multiple cropping is possible. The areas most suited for important crops have been discussed.

Under the All India Coordinated Agronomic Research Project, sixty important crop sequences for achieving high productivity at different centres in the country have been identified. Out of these, 25 crop sequences involve rice as the important crop.

Studies on manure and fertilizer use in selected crop sequences have indicated that with the use of farm yard manure to kharif crop, some economy in fertilizer can be affected for moderate yield levels. However, for obtaining high crop responses, recommended fertilizer dose, to both the crops in a rotation has been found to be very essential.

Studies on intercropping in wide spaced row crops like cotton have indicated the possibility of growing crops like greengram, cowpea and onion without reducing the yield of the main crop. Similarly intercropping studies in sugarcane have indicated the possibility of growing crops like radish, onion, dwarf-wheat, cowpea and lady's finger. Planting pattern of sugarcane can be modified to facilitate intercropping without loss in yield. The gross returns were increased without affecting the yield of main crop in these studies.

In rainfed areas, experiments at selected centres are in progress to find out the most suitable crop for kharif and rabi seasons. Also, double cropping systems, in areas where the rainfall is for extended period and soils are moisture retentive are being tried. Some location specific results have been presented.

Table 1. Important states from the point of area covered under individual crops.

1.	Rice	Assam (71)	W.Benggal (71)	Orissa (54)	Bihar (49)	Tamilnadu (35)
		Kerala (30)	Jammu & Kashmir (29)	Madhya Pradesh (21)	Uttar Pradesh (19)	Karnataka (11)
		Himachal Pradesh (15)	Punjab (7)	Haryana (5)	Gujarat (5)	
2.	Wheat :	Punjab (39)	H.P. (36)	U.P. (24)	Haryana (21)	M.P. (17)
		J & K (11)	Binar (10)	Rajasthan (9)		
3.	Sorghum :	Mahara-shtra (28)	Karnataka (21)	Gujarat (13)	M.P. (11)	Tamilnadu (11)
		A.P. (10)	Rajasthan (8)	Haryana (5)		
4.	Cotton :	Gujarat (17)	Maharashtra (14)	Karnataka (10)	Punjab (7)	
5.	Maize :	J & K (30)	H.P. (28)	Punjab (10)	A.P. (7)	
6.	Pearl millet (Bajra) :	Rajasthan (30)	Gujarath (20)	Haryana (19)	Maharashtra (11)	
		Tamilnadu (7)	Karnataka (5)	Andhra Pradesh (5)		
7.	Other millets :	H.P. (28)	M.P. (18)	A.P. (7)	T.N. (7)	
8.	Bengal gram :	Haryana (22)	Rajasthan (9)	M.P. (8)	Punjab (7)	
9.	Pulses :	Bihar (11)	Maharashtra (9)	Karnataka (9)	A.P. (9)	
		M.P. (9)	Orissa (9)			
10.	Groundnut:	Gujarath (17)	T.N. (13)	A.P. (11)	Karnataka (9)	

(N.B. - Figures in parenthesis indicate percentage area covered in respective states).

Table 2. Crop sequences giving high productivity at Agronomic Research Centres.

Sl No.	Crop Sequence	Centre	
1	Rice-rice-rice	1. Bhubaneswar 2. Tirupati 3. Anantharajpet 4. Maruteru	5. Mangalore 6. Bhavanisagar 7. Karamana
2	Rice-wheat-rice	1. Varanasi 2. Kalyani 3. Mantripukri	4. Titabar 5. Basudeopur
3	Rice-wheat-green gram	1. Purafarm 2. Varanasi 3. Delhi 4. Kathulia farm 5. Navasari 6. Karjat	7. Basudeopur 8. Kharagpur 9. Sabour 10. Rudrur 11. Bichpuri
4	Rice-wheat-cowpea	1. Raipur 2. Jabalpur	3. Chiplima 4. Varanasi
5	Rice-wheat-cowpea (fodder)	1. Jabalpur	
6	Rice-wheat-sorghum	1. Karjat	
7	Rice-wheat	1. Bagatishero 2. Talab Tillo 3. Palampur 4. Masodha 5. Banswara 6. Navasari	7. Basudeopur 8. Kharagpur 9. Kalyani 10. Raipur 11. Mantripukri
8	Rice-finger millet-rice	1. Maruteru	
9	Rice-rice-finger millet	1. Mangalore	
10	Rice-wheat-maize	1. Raipur 2. Kalyani	3. Kharagpur
11	Rice-maize-cowpea	1. Bhubaneswar	2. Chiplima
12	Rice-rice-groundnut	1. Bhavanisagar	2. Thanjavur
13	Rice-maize-green gram	1. Sabour	
14	Rice-rice-maize	1. Bhavanisagar	
15	Rice-rice-blackgram	1. Karaiyiruppu	

Sl No.	Crop Sequence	Centre	
16	Rice-rice-greengram	1. Thanjavur	
17	Rice-wheat-clusterbean	1. Raipur	
18	Rice-rice	1. Tanjavur 2. Tirupathi	3. Chiplima
19	Rice-maize	1. Rudrur	
20	Rice-potato-greengram	1. Kalyani	
21	Rice-potato-groundnut + greengram	1. Kharagpur	
22	Rice-rice-cowpea	1. Mangalore	2. Karamana
23	Rice-potato-cowpea	1. Bhubaneswar	
24	Rice-Bengalgram-pearl millet	1. Rudrur	
25	Rice-Oats + cowpea (F)	1. Palampur	
26	Maize-wheat-greengram	1. Pantnagar 2. Ludhiana 3. Banaswara	4. Kathulia farm 5. Indore
27	Maize-wheat-cowpea(F)	1. Indore 2. Junagadh	3. Pura farm
28	Maize-wheat-cheena	1. Pura farm 2. Kathulia farm	3. Varanasi
29	Maize-wheat-groundnut	1. Akola	2. Rahuri
30	Maize-rice-blackgram	1. Karaiyiruppu	
31	Maize-potato-greengram	1. Pantnagar 2. Ludhiana	3. Akóla
32	Maize-potato + wheat-greengram	1. Pantnagar	
33	Maize-potato + wheat - cowpea (F)	1. Pura farm	
34	Maize-potato-maize	1. Pantnagar	
35	Maize-potato	1. Palampur	2. Talab Tillo
36	Maize-wheat-clusterbean (F)	1. Hissar	
37	Maize-wheat	1. Talab Tillo 2. Pantnagar 3. Palampur 4. Hissar	5. Senore 6. Junagadh 7. Gwalior 8. Nandyal

Sl No	Crop Sequence	Centre	
38	Maize-potato + wheat	1. Talab Tillo	
39	Maize-rice	1. Karaiyiruppu	
40	Maize-wheat-greengram(F)	1. Hissar	
41	Pearl millet-wheat-greengram	1. Hanumangarn 2. Bichpuri	3. Jagudan 4. Junagadh
42	Pearl millet-onion-cowpea	1. Siruguppa	
43	Pearl millet-wheat-cowpea (F)	1. Bichpuri	2. Hissar
44	Pearl millet-wheat-clusterbean (F)	1. Hissar	
45	Pearl-wheat	1. Hanumangarh 2. Hissar	3. Junagadh 4. Gwalior
46	Sorghum-wheat-greengram	1. Jhansi 2. Rahuri	3. Jabalpur 4. Sehore
47	Sorghum-potato-greengram	1. Akola	2. Kathulia farm
48	Sorghum-wheat-pearl millet	1. Siruguppa	
49	Sorghum-wheat-maize	1. Akola	
50	Sorghum-wheat-Jowar	1. Siruguppa	
51	Sorghum-wheat-cowpea(F)	1. Senore	2. Jhansi
52	Sorghum-wheat	1. Jhansi 2. Indore	3. Akola 4. Gwalior
53	Greengram-wheat-sorghum(F)	1. Rahuri	
54	Greengram-wheat-cowpea(F)	1. Gwalior	
55	Greengram-wheat-maize(F)	1. Sehore	
56	Finger millet-rice-cowpea(F)	1. Bhubaneswar	
57	Chillies-Bengalgram Maize+cowpea (F)	1. Siruguppa	
58	Radish-onion-cowpea	1. Siruguppa	
59	Soyabean-wheat	1. Indore 2. Palampur	3. Jabalpur
60	Wheat-greengram	1. Nandyal 2. Senore	3. Jagudan

Table 3.1. Effect of farm yard manure and fertilizer levels on crop yields in selected sequences.

Soil type/State/ Centre/Years	Varieties tried	No. of trials	Season	Yield in quintals per hectare at									
				Kh F_0N_0 Rb F_0N_0	F_0N_0 F_0N_{60}	F_0N_{120} F_0N_{60}	$F_0N_{120}P_{60}$ F_0N_{60}	$F_0N_{120}P_{60}K_{60}$ F_0N_{60}	$F_{12}N_0$ F_0N_0	$F_{12}N_0$ F_0N_{60}	$F_{12}N_0$ $F_0N_{60}P_{60}$	$F_{12}N_{60}$ F_0N_{60}	$F_{12}N_{90}$ F_0N_{60}
Mixed Red & Black						Rice-Rice							
Tamil Nadu Tirunelveli 1974-75 to 1976-77 (3 years)	ADT-31 IR-20 Culture-5 CR-146-1055-225	32	Kharif	49.9	50.5	57.3	65.0	68.3	55.3	55.6	55.4	60.1	58.7
			Rabi	46.6	55.4	56.9	56.2	56.5	47.8	54.2	60.8	58.7	57.1
			Total:	96.5	105.9	110.2	121.2	124.8	103.1	109.8	116.2	118.8	115.8
Red Sandy													
Karnataka Mysore 1975-76 to 1976-77 (2 years)	MR-136	16	Kharif	29.4	29.3	49.9	54.0	61.5	38.4	38.7	38.8	45.8	49.2
			Rabi	37.8	46.8	56.6	58.7	62.9	41.8	51.4	60.7	51.7	54.5
			Total:	67.2	76.1	106.5	102.7	124.4	80.2	90.1	99.5	97.5	103.7
Red Loamy													
Orissa Puri 1975-76 to 1976-77 (2 years)	Jagannath Kumar Sakti	11	Kharif	25.9	27.1	40.8	45.0	46.8	32.6	32.3	32.7	39.2	41.7
			Rabi	23.0	33.4	33.7	35.7	36.3	27.4	37.8	39.7	37.9	38.5
			Total	48.9	60.5	74.5	80.7	83.1	60.0	70.1	72.4	77.1	80.2
		59	Kh.Mean	39.9	40.4	52.2	58.3	62.5	46.5	46.7	46.7	52.3	53.0
			Rb.Maan	39.8	49.0	52.5	53.1	54.5	42.4	50.4	56.8	52.9	52.9
			Total	79.7	89.4	104.7	111.4	117.0	88.9	97.1	103.5	105.2	105.9

Table 3.2. Effect of farm yard manure and fertilizer levels on crop yuelds in selected sequences.

Soil type/State/ Centre/Years	Varieties tried	No. of trials	Season	Yield in quintals per hectare at									
				Kh. F_0N_0	F_0N_0	F_0N_{120}	$F_0N_{120}P_{60}$	$F_0N_{120}P_{60}N_{60}$	$F_{12}N_0$	$F_{12}N_0$	$F_{12}N_0$	$F_{12}N_{60}$	$F_{12}N_{90}$
				Rb. F_0N_0	F_0N_{60}	F_0N_{60}	F_0N_{60}	F_0N_{60}	F_0N_{60}	F_0N_{60}	$F_0N_{60}P_{60}$	F_0N_{60}	F_0N_{60}
							Rice-Wheat						
Alluvial													
Bihar	Rice: IR-20	87	Kharif	21.8	21.8	4[illegible].1	47.1	49.7	31.8	32.0	35.4	41.4	45.6
Bhagalpur	Wheat: S-308		Rabi	15.7	26.5	27.6	29.5	30.2	16.8	28.4	33.5	29.5	29.9
1974-75 to 76-77 (3 years)	R-R-21		Total	37.5	48.3	69.7	76.6	79.9	48.6	60.4	68.9	70.9	75.5
Red and Yellow													
Manipur	Rice: IR-24	46	Kharif	33.3	34.4	44.1	48.5	53.9	44.4	46.6	47.5	54.4	55.9
Manipur	Wheat: S-308		Rabi	5.7	8.6	10.4	12.8	13.6	7.4	11.0	14.9	13.3	14.2
1974-75 to 76-77	Sonalika		Total	39.0	43.0	54.5	61.3	67.5	51.8	57.6	62.4	67.7	70.1
		133	Kh.Mean	25.8	26.2	42.8	47.6	51.2	36.2	37.1	39.6	45.9	49.2
			Rb.Mean	12.2	20.3	21.7	23.7	24.5	13.6	22.4	23.9	23.9	24.5
			Total	38.0	46.5	64.5	71.3	75.7	49.8	59.5	66.7	69.8	73.7

Table 3.3. Effect of farm yard manure and fertilizer levels on crop yields in selected sequences.

Soil type/State/ Centre/Year	Varieties tried	No. of trials	Season	Kh. F_0N_0	F_0N_0	F_0N_{120}	F_0N_{120} P_{60}	F_0N_{120} $P_{60}K_{60}$	$F_{12}N_0$	$F_{12}N_0$	$F_{12}N_0$	$F_{12}N_{60}$	$F_{12}N_{90}$
				Rb. F_0N_0	F_0N_{60}	F_0N_{60}	F_0N_{60}	F_0N_{60}	F_0N_0	F_0N_{60}	F_0N_{60} P_{60}	F_0N_{60}	F_0N_{60}
				Yield in quintals per hectare at									
				Maize-Wheat									
Alluvial													
Uttar Pradesh	Maize: T-41	18	Kharif	8.3	7.9	17.3	20.0	20.6	11.1	11.2	11.8	15.2	17.5
Bulandshahr	Wheat: HD-2009		Rabi	24.6	40.3	41.2	43.1	43.0	30.1	44.0	50.3	45.7	46.9
1974-75 to 76-77 (3 years)		Total		32.9	48.2	58.5	63.1	63.6	41.2	55.2	62.1	60.9	64.4
Brown Hills													
Himachal Pradesh	Maize: Vijaya	51	Kharif	15.6	15.5	27.8	31.1	34.0	23.8	23.9	23.6	29.6	32.5
Kangra	Wheat: S-308 K. Sona		Rabi	15.2	23.9	24.6	25.5	26.2	18.8	26.1	29.6	26.3	27.4
1974-75 to 76-77 (3 years)	Sonalika		Total	30.8	39.4	52.4	56.6	60.2	42.6	50.0	53.2	55.5	59.9
		69	Kh. Mean	13.7	13.5	25.1	28.2	30.5	20.5	20.6	20.5	25.8	28.6
			Rb. Mean	17.7	28.2	28.9	30.1	30.6	21.8	30.8	35.0	31.4	32.5
			Total	31.4	41.7	54.0	58.3	61.1	42.3	51.4	55.5	57.2	61.1
				Sorghum-Wheat									
Mixed Red and Black													
Karnataka	Sorghum:	22	Kharif	15.8	16.1	25.6	31.3	36.6	22.8	22.4	23.2	26.3	29.0
Chitradurga	CSH-5		Rabi	5.3	9.0	10.5	11.1	12.8	6.0	10.9	16.0	12.2	14.2
1975-76 to 76-77 (2 years)	Wheat		Total	21.1	25.1	36.1	42.4	49.4	28.8	33.3	39.2	38.5	43.2

Table 3.4. Effect of farm yard manure and fertilizer levels on crop yields in selected sequences.

Soil type/State/ Centre/Year	Varieties tried	No. of trials	Season	Yield in quintals per hectare at									
				Kh. F_0N_0	F_0N_0	F_0N_{120}	$F_0N_{120}P_{60}$	$F_0N_{120}P_{60}N_{60}$	$F_{12}N_0$	$F_{12}N_0$	$F_{12}N_0$	$F_{12}N_{60}$	$F_{12}N_{90}$
				Rb. F_0N_0	F_0N_{60}	F_0N_{60}	F_0N_{60}	F_0N_{60}	F_0N_0	F_0N_{60}	$F_0N_{60}P_{60}$	F_0N_{60}	F_0N_{60}
				Pearl Millet - Wheat									
Alluvial													
Haryana	Pearl millet:	38	Kharif	8.2	8.5	15.1	17.8	18.2	11.6	12.0	12.1	15.5	16.7
Gurgaon	HB-3		Rabi	14.2	18.3	23.4	25.4	27.2	19.3	23.0	30.0	26.9	28.1
1974-75 to 76-77	PHB-14		Total	22.4	26.8	38.5	43.2	45.4	30.9	35.0	42.1	42.4	44.8
(3 years)	Wheat: S-227												
	HD-2009												
Calcareous Sierozem													
Haryana	Pearl millet:	76	Kharif	9.7	10.0	19.2	22.2	23.9	13.9	14.2	14.3	17.8	19.6
Jind	HB-3		Rabi	19.1	30.9	32.1	33.5	31.5	23.3	33.6	42.6	34.0	34.9
1974-75 to 76-77	PHB-14		Total	28.8	40.9	51.3	55.7	55.4	37.2	47.8	56.9	51.8	54.5
(3 years)	Wheat: HD-2009,												
	K. Sona												
		114	Kh. Mean	9.2	9.5	17.5	20.7	22.0	13.1	13.5	13.6	17.0	18.6
			Rb. Mean	17.5	26.7	29.2	30.8	30.1	22.0	30.1	38.4	31.6	32.6
			Total	26.7	36.2	47.0	51.5	52.1	35.1	43.6	52.0	48.6	51.2

Table 4.1 Effect of different levels of fertilizers on crop yields in selected crop sequences.

Soil type/State/ Centre/Year	Varieties tried	No. of trials	Season	Yield (kg/ha)			Response in quintals per hectare at						
				$N_0P_0K_0$	$N_{120}P_{60}K_{60}$	$N_{90}P_{45}K_{45}$	$N_{90}P_{90}K_0$	$N_{90}P_0K_{90}$	$N_{60}P_{30}K_{30}$	$N_{60}P_{60}K_0$	$N_{60}P_0K_{60}$	$N_{60}P_{30}K_{30}$	$N_{60}P_0K_0$
				$N_0P_0K_0$	$N_{120}P_{60}K_{60}$	$N_{120}P_{60}K_{60}$	$N_{90}P_0K_{90}$	$N_{90}P_{90}K_0$	$N_{90}P_{90}K_0$	$N_{90}P_{45}K_{45}$	$N_{60}P_{60}K_0$	$N_{60}P_{30}K_{30}$	$N_{60}P_{30}K_{30}$
								Rice-Rice					
Alluvial													
Tamil Nadu	IR-20	76	Kharif	32.2	12.0	9.6	10.1	9.0	9.8	10.8	1.5	10.2	8.8
Chingleput	Kannagi		Rabi	30.1	19.2	13.5	8.3	11.7	12.0	10.8	10.5	10.9	9.4
1974-75 to 76-77 (3 years)	IET-2222		Total	62.3	26.2	23.1	18.4	20.7	21.8	21.6	19.0	21.1	18.2
Coastal Alluvial													
Pondichery	IR-24	23	Kharif	21.3	29.8	23.0	23.7	16.9	16.4	17.4	12.8	16.4	7.7
Pondichery	ADT-31		Rabi	15.9	18.7	19.3	10.5	17.2	18.5	16.9	15.3	11.9	12.5
1974-75 to 75-76 (2 years)			Total	37.2	48.5	42.3	34.2	34.1	34.9	34.3	28.1	28.3	20.2
Red Sandy													
Carnataka	MR-136	10	Kharif	30.9	24.0	17.6	13.8	16.6	15.2	10.4	11.9	17.7	9.5
Aysore			Rabi	31.7	35.4	29.7	20.8	19.5	22.4	23.3	19.5	23.4	20.5
1974-75 to 75-76 (2 years)			Total	62.6	59.4	47.3	34.6	36.1	37.6	33.7	31.4	41.1	30.0
Red Loamy													
Orissa	Pankaj	40	Kharif	19.7	25.7	18.0	18.4	9.9	13.5	15.6	7.3	13.4	4.1
Balasore	Ratha		Rabi	26.2	33.7	32.0	14.4	25.9	27.3	23.1	16.9	16.0	13.0
1974-75 to 76-77 (3 years)	Jagannath MR-1560		Total	45.9	59.4	50.0	32.8	35.8	40.8	38.7	24.2	29.4	17.1

Table 4.1. (Cont'd)

Soil type/State/ Centre/Year	Varieties tried	No. of trials	Season	Yield (kg/ha)	Response in quintals per hectare at									
				$N_0P_0K_0$	$N_{120}P_{60}K_{60}$	$N_{90}P_{45}K_{45}$	$N_{90}P_{90}K_0$	$N_{90}P_0K_{90}$	$N_{60}P_{30}K_{30}$	$N_{60}P_{60}K_0$	$N_{60}P_0K_{60}$	$N_{60}P_{30}K_{30}$	$N_{60}P_0K_0$
				$N_0P_0K_0$	$N_{120}P_{60}K_{60}$	$N_{120}P_{60}K_{60}$	$N_{90}P_0K_{90}$	$N_{90}P_{90}K_0$	$N_{90}P_{90}K_0$	$N_{90}P_{45}K_{45}$	$N_{60}P_{60}K_0$	$N_{60}P_{30}K_{30}$	$N_{60}P_{30}K_{30}$
Laterite													
Kerala	Jaya	49	Kharif	28.0	15.2	11.4	9.6	7.5	7.2	8.0	5.3	7.3	3.5
Trivendrum			Rabi	23.6	13.7	11.6	7.4	8.2	7.9	8.3	6.1	7.6	5.1
1975-76 to 76-77			Total	51.6	28.9	23.0	17.0	15.7	15.1	16.3	11.4	14.9	8.6
Laterite													
Kerala	Jaya	39	Kharif	33.1	14.5	11.3	12.1	9.7	10.5	11.0	8.3	11.0	7.0
Malappuram			Rabi	30.6	14.0	11.1	9.3	10.7	9.2	9.2	8.4	8.8	8.3
1975-76 to 76-77 (2 years)			Total	63.7	28.5	22.4	21.4	20.4	19.7	20.2	16.7	19.8	15.3
Laterite													
Maharashtra	R-24	42	Kharif	20.7	11.9	12.3	13.2	11.2	9.3	11.7	8.7	11.1	5.4
Ratnagiri			Rabi	23.1	14.7	16.5	10.1	13.4	13.4	11.6	19.3	11.4	9.4
1975-76 to 76-77 (2 years)			Total	43.8	26.6	28.8	23.3	24.6	22.7	23.3	18.0	22.5	14.8
Laterite													
West Bengal	Jaya	27	Kharif	33.5	15.9	10.9	10.6	10.0	9.3	8.2	7.7	10.0	5.4
Midnapore	Pankaj		Rabi	34.2	15.5	17.3	12.5	11.1	9.9	14.3	8.9	11.5	10.9
1975-76 to 76-77 (2 years)	Pusa		Total	67.7	31.4	28.2	23.1	21.1	19.2	22.5	16.6	21.5	16.3
Laterite													
Kerala	Jaya	20	Kharif	22.8	20.9	14.4	13.0	11.5	9.5	9.4	7.5	9.7	5.4
Quilon			Rabi	25.3	19.0	18.6	11.6	12.9	13.4	13.1	8.4	9.5	9.5
1974-75 (1 year)			Total	48.1	39.9	33.0	24.6	24.4	22.9	22.5	15.9	19.2	14.9

Table 4.1. (Cont'd)

Soil type/State/ Centre/Year	Varieties tried	No. of trials	Season	Yield (kg/ha) Response in quintals per hectare at									
				N_0P_0 K_0	$N_{120}P_{60}$ K_{60}	$N_{90}P_{45}$ K_{45}	$N_{90}P_{90}$ K_0	$N_{90}P_0$ K_{90}	$N_{60}P_{30}$ K_{30}	$N_{60}P_{60}$ K_0	$N_{60}P_0$ K_{60}	$N_{60}P_{30}$ K_{30}	$N_{60}P_0$ K_0
				N_0P_0 K_0	$N_{120}P_{60}$ K_{60}	$N_{120}P_{60}$ K_{60}	$N_{90}P_0$ K_{90}	$N_{90}P_{90}$ K_0	$N_{90}P_{90}$ K_0	$N_{90}P_{45}$ K_{45}	$N_{60}P_{60}$ K_0	$N_{60}P_{30}$ K_{30}	$N_{60}P_{30}$ K_{30}
Laterite													
Karala Trichur 1974-75 (1 year)	Triveni	18	Kharif	30.2	14.1	11.8	11.2	9.4	9.6	9.6	8.1	10.6	8.1
			Rabi	28.2	12.5	11.8	9.5	9.3	9.8	9.1	8.6	8.6	8.1
			Total	58.4	26.6	23.6	20.7	18.7	19.4	18.7	1.67	19.2	16.2
Laterite													
Goa Goa 1974-75 (1 year)	IR-8	22	Kharif	22.8	17.5	16.9	13.1	11.6	14.3	12.6	11.7	15.4	9.4
			Rabi	33.4	16.8	17.5	9.3	8.7	10.6	10.2	9.4	8.8	7.1
			Total	56.2	34.3	34.4	22.4	20.3	24.9	52.8	20.1	24.2	16.5
Mixed Red and Black													
Tamil Nadu Tirunelveli 1974-75 to 76-77 (3 years)	ADT-31 IR-20 Culture-5 CR-141-7055	52	Kharif	50.5	26.1	20.2	19.5	13.4	12.9	15.6	14.5	13.4	11.5
			Rabi	48.4	21.3	20.9	12.8	13.2	12.0	11.8	9.7	10.4	11.3
			Total	98.9	47.4	41.1	32.3	26.6	24.9	27.4	24.2	23.8	22.8
		418	Kh.Mean	30.1	18.0	14.8	13.7	10.7	10.9	11.8	9.1	11.5	7.1
			Rb.Mean	30.0	19.0	17.4	10.4	13.2	13.2	12.6	11.3	10.9	9.7
			Total	60.1	37.0	32.2	24.1	23.9	24.1	24.4	20.4	22.4	16.8

Table 4.2. Effect of different levels of fertilizers on crop yields in selected sequences.

Soil type/State District/Year	Varieties tried	No. of trials	Season	Kh. $N_0P_0K_0$ Rb. $N_0P_0K_0$ Yield (kg/ha)[4]	Response in quintals per hectare at $N_{120}P_{60}K_{60}$ $N_{120}P_{60}K_{60}$	$N_{90}P_{45}K_{45}$ $N_{120}P_{60}K_{60}$	$N_{90}P_{90}K_0$ $N_{90}P_0K_{90}$	$N_{90}P_0K_{90}$ $N_{90}P_{90}K_0$	$N_{60}P_{30}K_{30}$ $N_{90}P_{90}K_0$	$N_{60}P_{60}K_0$ $N_{90}P_{45}K_{45}$	$N_{60}P_0K_{60}$ $N_{60}P_{60}K_0$	$N_{60}P_{30}K_{30}$ $N_{60}P_{30}K_0$	$N_0P_0K_0$ $N_{60}P_{30}K_{30}$
					Rice - Wheat								
Alluvial													
Uttar Pradesh Gorakhpur 1974-75 to 76-77 (3 years)	Rice: CR-44-35 Wheat: HD-1982	51	Kharif	24.8	17.3	14.8	14.2	11.2	10.8	12.0	8.5	10.8	7.6
			Rabi	17.7	25.6	25.2	16.2	21.4	20.9	19.7	15.7	15.2	14.6
			Total	42.5	42.9	40.0	30.4	32.6	31.7	31.7	24.2	26.0	22.2
Alluvial													
Uttar Pradesh Fatehpur 1974-75 to 76-77 (3 years)	Rice: Ratna IR-24 Wheat: HD-1982	56	Kharif	17.1	24.8	20.3	20.4	16.9	14.0	14.5	11.3	13.5	9.6
			Rabi	16.8	26.7	25.8	17.4	22.3	22.0	20.4	15.5	14.3	12.8
			Total	33.9	51.5	46.1	37.8	39.2	36.0	34.9	26.8	27.8	22.4
Alluvial													
Delhi Delhi 1974-75 (1 year)	Rice: Pusa-2-21 Wheat: HD-2009	11	Kharif	17.7	11.2	11.0	11.2	4.9	6.0	10.1	9.4	9.8	4.7
			Rabi	27.0	15.9	10.8	9.2	13.6	12.7	12.6	9.3	13.0	5.9
			Total	44.7	27.1	21.8	20.4	18.5	18.7	22.7	18.7	22.8	10.6
Alluvial													
Bihar Saran 1976-77 (1 year)	Rice: IR-20 Wheat: HD-1553	30	Kharif	19.5	26.3	21.1	22.6	16.3	14.8	15.0	11.4	16.6	7.8
			Rabi	18.5	24.2	22.6	15.1	18.0	17.5	15.9	11.5	11.5	10.2
			Total	38.0	50.5	43.7	37.7	34.3	32.3	30.9	22.9	28.1	18.0

Table 4.2. (Cont'd)

Soil type/State District/Year	Varieties tried	No. of trials	Season	Kh. $N_0P_0K_0$ / Rb. $N_0P_0K_0$ Yield (kg/ha)	Response in quintals per hectare at: $N_{120}P_{60}K_{60}$ / $N_{120}P_{60}K_{60}$	$N_{90}P_{45}K_{45}$ / $N_{120}P_{60}K_{60}$	$N_{90}P_{90}K_0$ / $N_{60}P_0K_{90}$	$N_{90}P_0K_{90}$ / $N_{90}P_{90}K_0$	$N_{60}P_{30}K_{30}$ / $N_{90}P_{90}K_0$	$N_{60}P_{60}K_0$ / $N_{90}P_{45}K_{45}$	$N_{60}P_0K_{60}$ / $N_{60}P_{60}K_0$	$N_{60}P_{30}K_{30}$ / $N_{60}P_{30}K_0$	$N_0P_0K_0$ / $N_{30}P_{30}K_{30}$
Mixed Red and Black													
Uttar Pradesh Banda 1974-75 to 76-77 (3 years)	Rice: IR-24 CR-44-35 Wheat: Raj. 911	50	Kharif	15.4	25.5	21.0	21.6	18.0	17.6	17.1	15.5	17.6	12.5
			Rabi	16.0	27.5	24.8	19.4	21.3	23.3	21.4	18.5	18.5	15.0
			Total	31.4	53.0	45.8	41.0	39.3	40.9	38.5	34.0	35.1	27.5
Mixed Red and Black													
Madhya Pradesh Bilaspur 1974-75 to 76-77 (3 years)	Rice: Ratna Wheat: S-227 Shera K. Sona	52	Kharif	15.9	25.8	19.0	17.3	11.1	1.57	14.6	9.4	16.0	5.6
			Rabi	13.5	22.7	20.2	10.4	14.3	14.1	14.7	10.5	13.0	11.9
			Total	29.4	48.5	39.2	27.7	25.4	29.8	29.3	19.9	29.0	17.5
Laterite													
West Bengal Midnapore 1974-75 to 75-76 (2 years)	Rice: Jaya Wheat: S-308 Sonalika	25	Kharif	26.3	18.5	14.8	15.3	13.4	10.6	11.9	9.7	11.9	4.9
			Rabi	12.1	10.9	12.6	7.9	12.0	12.3	10.5	18.1	8.5	6.9
			Total	38.4	29.4	27.4	23.2	25.4	22.9	22.4	19.8	20.4	11.8
		285	Kh. Mean	19.0	22.8	18.4	18.4	14.2	14.0	14.2	11.0	14.2	8.2
			Rb. Mean	16.4	23.8	22.4	14.9	18.8	18.9	17.8	14.0	14.1	12.3
			Total	35.4	46.6	40.8	33.3	33.0	32.9	32.0	25.0	28.3	20.5

Table 4.3. Effect of different levels of fertilizers on crop yields in selected sequences.

Soil type/State District/Year	Varieties tried	No. of trials	Season	Kh. $N_0P_0K_0$ Rb. $N_0P_0K_0$ Yield (kg/ha)	Response in quintals per hectare at $N_{120}P_{60}K_{60}$ $N_{120}P_{60}K_{60}$	$N_{90}P_{45}K_{45}$ $N_{120}P_{60}K_{50}$	$N_{90}P_{90}K_0$ $N_{90}P_0K_{90}$	$N_{90}P_0K_{90}$ $N_{90}P_{90}K_0$	$N_{60}P_{30}K_{30}$ $N_{90}P_{90}K_0$	$N_{60}P_{60}K_0$ $N_{90}P_{45}K_{45}$	$N_{60}P_0K_{60}$ $N_{60}P_{60}K_0$	$N_{60}P_{30}K_{30}$ $N_{60}P_{30}K_0$	$N_0P_0K_0$ $N_{60}P_{30}K_{30}$
					Maize - Wheat								
Alluvial Uttar Pradesh Bulandshahr 1974-75 to 76-77 (3 years)	Maize: KT-41 T-41 Wheat: HD-2009	47	Kharif Rabi Total	9.1 21.4 30.5	18.7 37.2 55.9	13.7 34.8 48.5	15.8 21.2 37.0	11.1 30.9 42.0	9.6 30.2 39.8	11.8 25.8 37.6	7.0 23.3 30.3	9.8 19.7 27.5	6.1 18.4 24.5
Alluvial Punjab Jullundur 1974-75 to 76-77 (3 years)	Maize: Ganga-5 Wheat: HD-2009 S-229 K-Sona	63	Kharif Rabi Total	15.7 22.2 37.9	15.9 25.7 41.6	12.4 24.4 36.8	13.5 18.0 31.5	9.6 21.9 31.5	10.2 22.5 32.7	10.3 20.7 31.0	8.3 18.0 26.3	9.6 16.8 26.4	6.9 15.1 22.0
Alluvial Bihar Saran 1975-76 (1 year)	Maize: G.Safed Wheat: Sonalika	223	Kharif Rabi Total	12.7 14.9 27.6	13.8 24.0 37.8	10.9 23.7 34.6	11.2 15.8 27.0	7.9 19.9 27.8	8.3 20.7 29.0	9.2 19.5 28.7	4.7 14.8 19.5	7.3 15.4 22.7	3.5 15.1 18.6
Sub-mountaneous Himachal Pradesh Una 1974-75 to 76-77 (3 years)	Maize: V. Composite Vijaj-1 HD-2000 Shailaja	65	Kharif Rabi Total	19.9 23.6 43.5	17.1 25.5 42.6	13.6 25.2 38.8	12.1 17.9 30.0	12.1 21.1 33.2	10.5 20.7 31.2	10.6 19.0 29.6	8.7 16.7 25.4	10.2 17.9 28.1	6.8 17.2 24.0
		198	Kh.Mean Rb.Mean Total	15.2 21.6 36.8	16.7 28.2 44.9	12.9 27.1 40.0	13.3 18.5 31.8	10.6 23.5 34.1	9.9 23.5 33.4	10.6 21.2 31.8	7.7 18.5 26.2	9.6 17.7 27.3	6.3 16.6 22.9

Table 4.4. Effect of different levels of fertilizers on crop yields in selected sequences.

Soil type/State/ Centre/Years	Varieties tried	No. of trials	Season	Kh. / Rb.	Yield (kg/ha)			Responses in quintals per hectare						
				Kh.	N_0P_0 K_0	$N_{120}P_{60}$ K_{60}	$N_{90}P_{45}$ K_{45}	$N_{90}P_{90}$ K_0	$N_{90}P_0$ K_0	$N_{60}P_{30}$ K_{30}	$N_{60}P_{60}$ K_0	$N_{60}P_0$ K_{60}	$N_{60}P_{30}$ K_{30}	$N_{60}P_{30}$ K_{30}
				Rb.	N_0P_0 K_0	$N_{120}P_{60}$ K_{60}	$N_{120}P_{60}$ K_{60}	$N_{90}P_{90}$ K_{90}	$N_{90}P_{90}$ K_0	$N_{90}P_{90}$ K_0	$N_{90}P_{45}$ K_{45}	$N_{60}P_{60}$ K_0	$N_{60}P_{30}$ K_{30}	$N_{60}P_{30}$ K_{30}
							Sorghum-Wheat							
Mixed Red and Black														
Karnataka	Jowar: CSH-1	29	Kharif		18.5	27.4	18.9	19.6	15.9	15.2	13.9	12.5	17.2	7.0
Chitradurga	CSH-5		Rabi		8.9	16.8	14.8	10.6	10.6	10.6	12.6	7.9	10.0	10.3
1974-75 to 76-77	Wheat: Safed larma		Total		27.4	44.2	34.7	30.2	26.5	25.8	26.5	20.4	27.2	17.3
(3 years)	S-227													
	UP-301													
Mixed Red and Black														
Madhya Pradesh	Jowar: N-3541	9	Kharif		8.6	7.3	5.4	5.0	5.9	5.0	4.3	6.0	5.3	3.7
Chattarpur	Wheat: Shera		Rabi		10.5	9.5	10.5	7.7	9.1	9.0	8.5	7.6	9.0	8.7
1976-77			Total		19.1	16.8	15.9	12.7	15.0	14.0	12.8	13.6	14.3	11.4
(1 year)														
Medium Black														
Mahadashtra	Jowar: CSH-1	30	Kharif		23.8	25.5	20.0	20.3	17.1	15.8	16.3	13.1	16.0	9.8
Dhulia	Wheat: HD-1593		Rabi		15.3	21.6	21.9	13.1	17.0	17.5	16.7	13.4	12.3	12.7
1976-77(1 year)			Total		39.1	47.1	41.9	33.4	34.1	33.3	33.0	26.5	28.5	28.5
Medium Black														
Maharashtra	Jowar: CSH-1		Kharif		18.0	28.6	21.9	22.5	18.9	15.2	16.2	13.8	14.2	10.2
Osmanabad	Wheat: HDM-1593		Rabi		8.4	16.6	15.9	9.3	11.7	11.2	9.4	7.3	6.0	5.2
1976-77 (1 year)			Total		26.4	45.2	37.8	31.8	30.6	26.4	25.6	21.1	20.2	15.4
		104	Kh.Mean		19.0	25.5	19.4	19.5	16.4	14.5	14.2	12.6	14.8	8.6
			Rb.Mean		10.7	17.5	16.9	10.6	12.7	12.7	12.3	9.3	9.2	9.1
			Total		29.7	43.0	36.3	30.1	29.1	27.2	26.5	21.9	24.0	17.7

Table 4.5. Effect of different levels of fertilizers on crop yields in selected sequences.

Soil type/State/ District/Year	Varieties tried	No. of trials	Season	Kh. / Rb.	$N_0P_0K_0$ Yield (kg/ha)	$N_{120}P_{60}K_{60}$	$N_{90}P_{45}K_{45}$	$N_{90}P_{90}K_0$	$N_{90}P_0K_{90}$	$N_{60}P_{30}K_{30}$	$N_{60}P_{60}K_0$	$N_{60}P_0K_{60}$	$N_{60}P_{30}K_{30}$	$N_{60}P_0K_0$
					Response in quintals per hectare at									
Alluvial							Pearl-Millet-Wheat							
Rajasthan Alwar 1974-75 (1 year)	Bajra: HB.3 Wheat: S-227	11	Kharif	Kh.	10.2	6.9	7.2	8.3	6.2	5.0	5.2	4.4	4.0	2.2
			Rabi	Rb.	19.4	10.2	10.8	10.3	10.8	9.5	9.4	7.3	7.3	7.0
			Total		29.6	17.1	18.0	18.6	18.0	14.5	14.6	11.7	11.3	9.2
Alluvial														
Haryana Gurgaon 1974-75 to 76-77 (3 years)	Bajra: HB-3 HB-4 Wheat: HD-2009 K-227	38	Kharif	Kh.	7.9	11.5	9.3	10.1	5.8	6.1	7.6	3.4	6.0	2.9
			Rabi	Rb.	15.0	19.6	18.8	10.8	16.3	15.1	14.1	11.4	11.2	9.5
			Total		22.9	31.1	28.1	20.9	22.1	21.2	21.7	14.8	17.2	12.4
Alluvial														
Delhi Delhi 1975-76 to 76-77	Bajra: HB-3 J-104 Wheat: HD-1982	28	Kharif	Kh.	13.1	8.9	7.2	6.9	6.5	5.9	7.2	5.9	6.1	4.4
			Rabi	Rb.	25.3	17.4	16.9	13.6	14.5	14.9	12.8	12.1	12.5	11.8
			Total		38.4	26.3	24.1	20.5	21.0	20.8	20.0	18.0	18.6	16.2
Red and Yellow														
Rajasthan Ajmer 1974-75 (1 year)	Barja-HB-3 Wheat: Raj.911	8	Kharif	Kh.	5.3	7.7	6.3	5.3	4.4	4.1	3.2	2.7	4.5	2.1
			Rabi	Rb.	12.7	10.6	10.5	7.7	7.6	6.3	6.0	4.3	4.4	4.1
			Total		18.0	18.3	16.8	13.0	12.0	10.4	9.2	7.0	8.9	6.2
Calcareous-Sierozem														
Haryana Jind 1974-75 to 76-77 (3 years)	Bajra: HB-3 PHB-14 Wheat: HB-2009 K. Sona	78	Kharif	Kh.	9.7	14.2	10.3	11.9	8.8	8.2	9.3	6.9	8.2	5.8
			Rabi	Rb.	21.3	30.7	29.0	17.7	25.0	24.7	22.5	19.1	16.6	17.3
			Total		31.0	44.9	39.3	29.6	33.8	32.9	31.8	26.0	24.8	23.1

Table 4.5. (Cont'd)

Soil type/State/ District/Year	Varieties tried	No. of trials	Season		Response in quintals per hectare at									
				Kh.	$N_0P_0K_0$	$N_{120}P_{60}K_{60}$	$N_{90}P_{45}K_{45}$	$N_{90}P_{90}K_0$	$N_{90}P_0K_{90}$	$N_{60}P_{30}K_{30}$	$N_{60}P_{60}K_0$	$N_{60}P_0K_{60}$	$N_{60}P_{30}K_{30}$	$N_{60}P_0K_0$
				Rb.	$N_0P_0K_0$ Yield (kg/ha)	$N_{120}P_{60}K_{60}$	$N_{120}P_{60}K_{60}$	$N_{90}P_0K_{90}$	$N_{90}P_{90}K_0$	$N_{90}P_{90}K_0$	$N_{90}P_{45}K_{45}$	$N_{60}P_{60}K_0$	$N_{60}P_{30}K_0$	$N_{60}P_{30}K_{30}$
Medium Black														
Gujarat Kaira 1975-76 (1 year)	Bajra: HB-3 Wheat: J-24	19	Kharif		7.2	7.3	4.9	5.2	4.5	3.2	4.1	3.4	4.4	3.8
			Rabi		18.8	22.9	21.4	15.3	15.8	16.4	16.9	13.3	13.1	13.3
			Total		26.0	30.2	26.3	20.5	20.3	19.6	21.0	16.7	17.5	17.2
Medium Black														
Rajkot 1975-76 (1 year)	Bajra: HB-3 Wheat: J-24	14	Kharif		14.7	5.0	4.3	5.4	2.7	4.8	4.3	2.7	4.0	1.6
			Rabi		15.8	8.5	9.0	6.2	7.3	7.4	7.0	6.3	7.2	6.2
			Total		30.5	13.5	13.3	11.6	10.0	12.2	11.3	9.0	11.2	7.8
Deep Black														
Maharashtra Dhulia 1975-76 (1 year)	Bajra: HB-3 Wheat: S-227	29	Kharif		17.0	18.3	14.0	15.9	12.4	9.2	9.8	7.3	9.7	5.4
			Rabi		16.8	23.2	22.9	14.2	18.8	18.8	17.0	13.9	14.1	13.7
			Total		33.8	41.5	36.9	30.1	31.2	28.0	26.8	21.2	23.8	19.1
Red Sandy														
Karnataka Bellary 1976-77	Bajra-PHB-14 Wheat-up.301	5	Kharif		7.6	12.6	11.7	7.2	7.2	6.6	5.7	7.5	7.6	3.3
			Rabi		4.4	7.4	6.9	4.8	3.9	4.1	4.8	3.3	3.0	3.4
			Total		12.0	20.0	28.6	12.0	11.1	10.7	10.5	10.8	10.6	6.7
		230	Kh.Mean		10.7	11.9	9.2	10.0	7.4	6.7	7.6	5.3	6.9	4.3
			Rb.Mean		18.9	22.1	21.2	13.7	17.9	17.6	16.2	13.6	12.9	12.6
			Total		29.6	34.0	30.4	23.7	25.3	24.3	23.8	18.9	19.8	16.9

Table 5. Effect of intercropping on yield of cotton and its economics. (Yield in kg/ha)

S_1 No.	Crop/Variety	NPK levels in kg/ha	Main crop			Intercrop			Gross return Ro/ha		
			1975-76	1976-77	Mean	1975-76	1976-77	Mean	1976-77	1975-76	Mean
			1. ARC, AKOLA (Maharashtra)								
1.	Cotton (entire) DHY-276 and MCU-5	50-25-25	581	726	653	-	-	-	1089	872	980
2.	Cotton (MCU-5) + G. gram (Kopergaon)	50-25-25	556	892	724	248	200	224	1658	1231	1444
3.	Cotton + G. Gram (-do-)	56-38-25	618	778	698	241	215	228	1511	1313	1412
4.	Cotton + G. gram (-do-)	63-50-0	567	841	704	263	267	265	1689	1271	1480
5.	Cotton + G. gram (-do-)	69-63-25	574	930	752	270	311	290	1893	1293	1593
6.	Cotton + G. gram (-do-)	75-75-25	563	848	705	239	292	264	1739	1224	1481
7.	Cotton + Cowpea (Dofasali)	50-25-25	541	867	704	430	356	393	1746	1349	1547
8.	Cotton + Cowpea (-do-)	60-40-25	541	663	603	489	337	413	1416	1423	1419
9.	Cotton + cowpea (-do-)	70-55-25	578	663	620	492	341	416	1421	1482	1451
10.	Cotton + Cowpea (-do-)	80-70-25	644	756	700	615	400	507	1635	1735	1685
11.	Cotton + Cowpea (-do-)	90-85-25	511	692	601	492	348	420	1473	1382	1427
			2. SIRUGUPPA (Karnataka)								
			1972-73	1973-74	Mean	1972-73	1973-74	Mean	1972-73	1973-74	Mean
1.	Entire Cotton (Hampi)	80-40-40	4439	1638	3039	-	-	-	5326	2457	3891
2.	Cotton (Hampi) + Cowpea (C-152)	-do-	3028	1354	2191	842	94	468	4476	2200	3318
3.	Cotton (Hampi) + Onion (Bellary) 4 rows	-do-	3486	1514	2500	5044	1215	3129	5696	2878	4287
4.	Cotton + Onion (Bellary) (2 rows)	-do-	4564	1672	3123	4769	713	2741	6908	2864	4886

Table 6. Yield and gross returns from sugarcane and intercrops under different planting pattern and intercropping at Siriguppa.

Sl No.	Treatment	Variety of main/inter-crops	Fertilizer (kg/ha) N	P	K	Duration days	Yield: Main crop (tonne/ha)	Inter-crop (kg/ha)	Gross returns (Rs./ha)	Index of gross returns
1.	Sugarcane alone (90 cms apart)	CO-419	250	75	75	390	108.226	-	14364	100
2.	Sugarcane + Onion (5 rows in between 2 rows of s.c.)	Bellary	100	50	100	120	107.392	10,800	19631	137
3.	Sugarcane + Radish (5 rows in between 2 rows of s.c.)	Local	75	37.5	37.5	50	100.268	25,890	18508	129
4.	Sugarcane + wheat (-do-)	UP-301	100	75	50	90	106.452	1,856	15291	106
5.	Sugacane + Cowpea (3 rows in between 2 rows of s.c.	C-152	25	50	25	120	108.000	1,470	17304	120
6.	Sugarcane + ladys finger (1 row on a ridge between 2 rows of s.c.)	Pusa Sawani	100	50	50	90	102.352	1,290	14211	99
7.	Sugarcane alone (paired rows of 60 cms with 120 cm gap between paired rows	CO-419	250	75	75	390	117,876	-	15694	100
8.	Sugarcane + Onion (7 rows in between 2 paired rows of s.c)	Bellary	100	50	100	120	109.677	5,630	17895	114
9.	Sugarcane + Radish (-do-)	Local	75	37.5	37.5	50	124.933	28,530	22531	144
10.	Sugarcane + wheat (-do-)	UP-301	100	75	50	90	111.694	1,310	15645	100
11.	Sugarcane + Cowpea (4 rows in between paired rows of s.c.)	C-152	25	50	25	120	112.769	1,050	17129	109
12.	Sugarcane + Ladys finger (2 rows in between 2 paired rows of s.c.)	Pusa Sawani	100	50	50	90	113.710	1,060	15162	97

Table 7. Choice of crops and cropping systems in rainfed areas.

Centre/Soil type (State)	Season	Crop	Variety	Duration	N-P-K levels kg/ha	Yield (kg/ha)	Main Produce			Net returns (Rs./ha)			
						1974-75	1975-76	76-77	Mean	1974-75	75-76	76-77	Mean
Talab-tills (Jammu and Kashmir)	Kharif	Maize	G.S.2	95	60-30-20	2062	1488	1517	1687	1468	721	742	1465
		Sorghum	CSH-1	125	60-30-20	505	-	749	627	-46	-	174	64
		Pearl millet	HY-3	101	40-20-20	-	-	720	720	-	-	269	269
		Cowpea	PS-42	90	40-60-40	-	505	-	505	-	191	-	191
		Blackgram	T-9	98	15-60-0	416	148	-	282	532	20	-	276
	Rabi	Mustard	R-2-18	105	30-30-30	-	324	1041	682	-	534	2326	1430
		-do-	BSH-1	129									
		Sunflower	EC.68413	173	60-40-30	56	-	-	56	-382	-	-	-382
		Safflower	A-300	173	60-40-30	1547	1488	-	1517	1706	1747	-	1726
		Rai	Rai-18	143	30-30-30	336	-	-	336	540	-	-	540
		Barley	KU-17	173	40-30-20	1800	1303	1547	1550	940	664	845	816
			PL-58	144									
		Gram	C-235	143	40-60-20	833	309	83	408	726	-22	-304	133
		Wheat	WG-357	143	60-30-30	3095	1190	1845	2065	2830	870	1557	1752
			HD-1981										
			JNK-6-T-206-B	128									
Double cropping	R_1 Kh.	Maize	GS-2	97	60-30-20	-	-	1928)	-	-	-	2373	-
	Rb.	Wheat	HD-1981	137	60-30-20	-	-	1511)					
	R_2 Kh.	Maize	GS-2	97	60-30-20	-	-	2148					
	Rb.	Safflower	A-300	145	45-30-30	-	-	1071				2373	
	R_3 Kh.	Maize	GS-2	97	60-30-20	-	-	1922	-	-	-	830	-
	Rb.	Gram	C-295	157	40-60-20	-	-	157					
	R_4 Kh.	Maize	GS-2	97	60-30-20	-	-	1898	-	-	-	1238	-
	Rb.	Mustard	RH-30	130	30-30-30	-	-	196					
	R_5 Kh.	Sesamum	R6-1	-	45-30-30	-	-	Failed	-	-	-	799	-
	Rb.	Wheat	HD-1981	137	60-30-30	-	-	1458					

Table 7. (Cont'd)

Centre/Soil type (State)	Season	Crop	Variety	Duration	N-P-K levels kg/ha	Yield (kg/ha)	Main Produce			Net returns (Rs./ha)			
						1974-75	1975-76	76-77	Mean	1974-75	75-76	76-77	Mean
Sehore (Deep-Black) (Madhya Pradesh)	Kharif	Sorghum	CS-3541	173	60-30-20	-	-	947	947	-	-	321	321
		Blackgram	KH-3	84	15-60-0	-	132	574	353	-	-12	872	430
			KH-5	94									
		G. gram	T-44	86)	15-60-0	-	46	61	53	-	-202	-178	-190
			Kopergaon	74)									
		Redgram	T-21	156	30-60-30	-	339	259	299	-	-158	30	-64
		Sesamum	K-11	76	45-30-30	-	34	37	35	-	-251	-243	-247
		Cowpea	Local	94	40-60-60	-	192	124	158	-	-232	-285	-258
	Rabi	Wheat	N-4	135	60-20-20	-	1450	642	1046	-	-	-	-
		Gram	T-3	137	40-60-20	-	741	228	484	-	-	-	-
		Lentil	JL-5	126	20-40-20	-	435	188	311	-	-	-	-
			JLS-1	113		-							
		Sunflower	EC-68415	131	60-45-30	-	740	265	502	-	-	-	-
		Safflower	Local	176	45-30-30	-	725	346	535	-	-	-	-
		Linseed	T-397	115	30-30-30	-	558	189	373	-	-	-	-
Junagadh Medium Black (Gujarat)	Kharif	Sorghum	CSH-5	126	60-30-20	-	-	1452	1452	-	-	694	694
		Sunflower	EC-68414	90	30-60-60	-	793	802	797	-	726	739	732
			EC-68415	110	30-60-30								
		Castor	GCH-3	90	40-40-0	-	540	1014	777	-		2231	1638
			CAN-CH-1	117									
		Groundnuts	SB-11	90	30-60-30	-	1844	369	1106	-	2554	133	1343
		Pearl millet	J-41	90	80-40-40	-	1146	1433	1289	-	320	532	426
			J-1399	98									
		Cotton	SRT-1	90	80-40-40	-	410	363	386	-	87	16	51
		Soybean	J-31	90	20-50-0	-	936	-	-	-	1050	-	1050
Chiplima (Red and Yellow) (Orissa)	Kharif	Groundnut	AK-12-24	120	30-60-60	1452	809	965	1085	1553	700	999	1013
			Polachi	115		1116							
			OG-71-3110-31										
		Rice	DR-92	90	60-30-20	1182	2429	1149	1264	475	1417	470	545
		Greengram	Kopergaon	60	15-60-0	640	579	390	536	724	650	348	574
		Blackgram	T-9	76	15-60-0	1190	786	1034	1216	2080	1296	1792	2144
						1855				3410			

Table 7. (Cont'd)

Centre/Soil type (State)	Season	Crop	Variety	Duration	N-P-K levels kg/ha	Yield (kg/ha)	Main Produce			Net returns (Rs./ha)			
						1974-75	1975-76	76-77	Mean	1974-75	75-76	76-77	Mean
		Finger millet	Dibya singh	80	40-20-20	1563 1357	1485	1057	1365	814 670	835	518	709
		Maize	Composite Jawahar	110	60-30-20	1425	1256	548	1076	598	549	225	390
		Cowpea	SEB-2	90	38-75-17	786	-	-	786	616	-	-	616
		Deccan hemp	AMV-1	140	50-25-17	2005	-	-	2005	2182	-	-	2182
	Rabi	Horsegram	Local	80	10-30-0	625	604	1177	802	715	607	1323	915
		Sesamum	S-14	90	25-12-12	99	70	25	64	72	10	-101	-19
		Mustard	M-27	75	30-15-15	-	161	44	102	-	228	88	158
		Bengalgram	-	65	40-60-20	-	-	55	55	-	-	-339	-339
		Greengram	P. Baisakhi	65	15-60-0	-	-	592	592	-	-	671	671
Akola (Medium-black) Maharashtra	Kharff	Jowar	CSH-4	115	60-30-20	5175	-	-	-	3223	-	-	-
		Bajra	HB-5	90	40-20-20	1144	-	-	-	521	-	-	-
		Cotton	K-147	200	50-25-25	1248	-	-	-	1522	-	-	-
		Sunflower	EC-68415	110	60-45-30	1934	-	-	-	2228	-	-	-
		Groundnut	SB-11	100	30-60-60	1273	-	-	-	1302	-	-	-
		Sesamum	No. 128	100	45-30-30	937	-	-	-	1975	-	-	-
Double cropping	R_1 Kh.	Jowar	CSH-1	110	60-30-20	2951	5349	-	4150	1801	3856	-	2828
	Rb.	Gram	Chaffa	105	40-60-20	411	549	-	480	-	-	-	-
	R_2 Kh.	Jowar	CSH-1	110	60-30-20	3254	5098	-	4176	2723	5294	-	4008
	Rb.	Safflower	N-7	135	45-30-30	861	1598	-	1209	-	-	-	-
	R_3 Kh	Greengram	Kopergoan	65	16-60-0	1262	922	-	1092	2142	1872	-	2007
	Rb.	Wheat	N-59	110	60-30-20	784	1018	-	901	-	-	-	-
	R_4 Kh.	Pearl millet	HB-3	90	40-20-20	1446	1604	-	1525	931	1484	-	1207
	Rb.	Wheat	N-59	110	60-30-20	570	212	-	391				

Table 7. (Cont'd)

Centre/Soil type (State)	Season	Crop	Variety	Duration	N-P-K levels kg/ha	Yield (kg/ha) 1974-75	Yield Produce 1975-76	76-77	Mean	Net returns (Rs./ha) 1974-75	75-76	76-77	Mean
	R_5 Kh.	Pearl millet	HB-3	90	40-20-20	1350	1728	-	1539	800	1373	-	1086
	Rb.	Gram		105	40-60-20	411	613	-	512				
	R_6 Kh.	Greengran	Kopergoan	65	15-60-0	1169	994	-	1031	2367	3588	-	2977
	Rb.	Safflower	N-7	135	45-30-30	826	1864	-	1345				
Hagari (Deep Black) Karnataka	Rabi	Sunflower	EC-68415	113	60-45-30	625	957	-	791	395	890	-	642
		Cotton	W-1	162	25-25-12	184	244	-	214	51	156	-	103
			GS-23	180									
		Sorghum	Muguti	120	60-30-20	824	474	-	649	177	-29	-	74
		Safflower	7-13-3	123	45-30-30	660	1379	-	1019	564	1595	-	1074
		Barley	NP-104	109	40-30-30	182	-	-	182	-193	-	-	-193
		Wheat	HD-1739	101	60-30-20	642	-	-	366	274	-	-	-6
			Bijaga Yellow	110		90	-	-	-	-286	-	-	-
		Linseed	S-16	125	45-30-30	-	573	-	573	-	1096	-	1096
		Gram	A-1	100	12-25-0	1150	-	-	1150	1254	-	-	1254

Net returns means value of main produce less the cost of fertilizers.

PRELIMINARY STUDY ON CROPPING SYSTEMS IN AGRICULTURAL RESEARCH INSTITUTE, YEZIN

Tun Saing, Pe Maung Thein and Toe Aung[1/]

Introduction

Multiple cropping systems have been practiced in Burma long before pre-war time, especially in the central plains of Dry Zone Tract and in some districts of Northern Burma. The concept of multiple cropping being the conservation of soil fertility by crop rotation and also to make advance the sustenance agriculture. Non-rice-based double cropping systems was predominant at that time under both rainfed and irrigated conditions, while the latter being restricted only to the rice-based double cropping systems in some areas. The traditional cropping patterns as seen in those days could be summarised as follows:

1. Sorghum-wheat or grain legumes
2. Early sessamum-sorghum or grain legumes
3. Sorghum-late sessamum
4. Maize-grain legumes
5. Maize or early sessamum-irrigated rice
6. Maize or sorghum-vegetables
7. Groundnut-grain legumes
8. Cotton-sorghum or grain legumes

On the contrary, rice was sown as monoculture in lower Burma until past-war time. It was only in 1952 that rice-based multiple cropping systems was introduced into delta area of lower Burma, when attempt was made to reduce the imports of jute and groundnut oil. The cropping patterns then followed in these areas could be summarized as follows:

1. Rice-groundnut
2. Jute-rice
3. Rice-black gram
4. Jute-rice-groundnut
5. Jute-rice-black gram

[1/] Deputy General Managers (Agronomy and Food Legumes Divisions) and Deputy Assistant General Manager (Oil Crop Division).

It is only since recently, the multiple cropping system becomes more imperative to feed the population with an annual growth rate of 2.4% and also to increase export trade from the agricultural sector. So the government is insisting on increased production of crops and planning to extend the area under rice-based multiple cropping systems. The following table shows the extent of multiple cropping in 1974-75.

Sr. No.	Cropping	Hectares (thousands)	Percent
1.	Gross sown area	9390	117.22
2.	Net sown area	8010	100.00
3.	Multiple cropping area	1380	17.22

The total area under multiple cropping has increased from 0.53 million hectares in 1961-62 to 1.38 million hectares in 1974-75 showing an annual growth rate of 1.23% which does not compensate with the population growth rate. Generally, the area under the multiple cropping is distributed to different cropping patterns as mentioned below:

Sr. No.	Cropping patterns	Cultivated area (thousand hectares)	Percent
1.	Pre-monsoon crop before rice	158	11.45
2.	Winter crop after rice	334	24.20
3.	Multiple cropping on dry land	519	37.64
4.	Mixed cropping on dry land	369	26.71
	Total	1380	100.00

If foregoing were the guide, slow increase in the multiple cropping areas might probably be due to low inputs which in turn leads to give less profitability in the process. With this in view, preliminary studies on rice-based multiple cropping systems have been carried out at the A.R.I., Yezin during the past two years. In the present report, the progress made subsequently will be referred to briefly.

Materials and Methods

The experiments were conducted on light sandy loam and loamy sand soils, having pH values ranging between 5 and 6. The area of each site varies from 0.25 to 1.00 hectare.

The normal annual rainfall on the test site is 1524 mm. with the maximum and minimum temperatures of 40°C and 17°C respectively. In 1976 total rainfall was 1496 mm. which could be taken as normal, whereas in 1977 the total precipitation was 984 mm. only lesser by 36 percent than the normal. However, pre- and late-monsoon crops tested were not much affected by drought as supported by the supplementary irrigation.

Both double and triple cropping systems were included in the studies and different cropping patterns tested during both the years were as follows:

A. 1976 season

	Monsoon		Late monsoon
1.	Rice	-	Cowpea
2.	Rice	-	Groundnut
3.	Rice	-	Black gram
4.	Rice	-	Green gram
5.	Rice	-	Pigeon pea
6.	Rice	-	Soybean

B. 1977 season

	Pre-monsoon	Monsoon	Late-monsoon
1.	Sessamum	Rice	-
2.	Jute	Rice	-
3.	-	Rice	Maize
4.	-	Rice	Sorghum
5.	Sessamum	Rice	Sunflower
6.	Vegetable maize	Rice	Sunflower
7.	Vegetable maize	Rice	Groundnut

Results and Discussion

In 1976, the highest monetary return was given by rice-cowpea followed next by rice-groundnut combination. It was observed that the next income of rice-cowpea was 31% higher than the rice-groundnut even though the total value of product of the latter was 23% higher than the former. The reason was that cost of cultivation for groundnut was approximately five times

higher than that of cowpea. Rice-black gram or rice-green gram were worth growing under rainfed conditions, whereas the last two were not much feasible because of low yields which might probably be due to unadaptable conditions (Table 1).

In 1977, out of four double cropping patterns, the highest net income was given by rice-maize and the results of the rest were more or less the same (Table 2). However, since maize, sorghum, sessamum and jute are of equal importance for local consumption, these crops should not be neglected and hence need further testing.

Of the three triple cropping patterns, vegetable maize-rice-groundnut gave the highest income, which exceeded by 23 and 16 percent over sessamum-rice-sunflower and maize-rice-sunflower respectively (Table 2). The reason was that among the crops used the monetary income given by vegetable maize and groundnut made the third pattern possible to get higher income than the other two.

Problems

Evaluation of different cropping patterns reported in this paper is inadequate since the study of component technology is still far beyond the scope of this organization. It needs to establish a seperate new division for this field and should provide to extend relevant methodology and technology into national programs. The major constraints then will be to have trained personals acquainted with research methodology and economic research in the cropping systems.

Table 1. Comparison of cropping patterns, conducted in ARI, Yezin, 1976.

Cropping patterns	Sowing date	Harvesting date	Yield/ ha (kg)	Basket Wt. (kg)	Price per basket (k)	Value of product (k)	Cost of cultivation (kyat)	Net income (kyat)
Rice	15-6-76	10-11-76	3667	21.0	10	1756.17	1143.61	612.56
Cowpea	14-11-76	4-4-77	1552	32.9	45	2134.00	424.84	1709.16
						3890.17	1568.45	2321.72
Rice	15-6-76	10-11-77	3667	21.0	10	1756.17	1143.61	612.56
Groundnut	25-11-76	15-4-77	736	10.0	50	3256.70	2074.80	1160.90
						4991.87	3218.41	1773.46
Rice	15-6-76	10-11-77	3667	21.0	10	1756.17	1143.61	612.56
Blackmung	20-11-76	22-3-77	485	32.7	60	889.20	424.84	464.36
						2645.37	1568.45	1076.92
Rice	2-6-76	31-10-76	3667	21.0	10	1756.17	1143.61	612.56
Greengram	14-11-76	4-2-77	509	32.7	50	778.05	424.84	353.21
						2534.22	1568.45	965.77
Rice	2-6-76	31-10-76	3667	21.0	10	1756.17	1143.61	612.56
Pigeon pea	14-11-76	26-4-77	477	32.7	40	582.92	424.84	158.08
						2339.09	1568.45	770.64
Rice	2-6-76	31-10-76	3667	21.0	10	1756.17	1143.61	612.56
Soybean	14-11-76	25.-2-77	267	32.7	65	531.05	424.84	106.21
						2287.22	1568.45	718.77

Table 2. Comparison of cropping patterns, conducted in ARI, Yezin, 1977.

Cropping patterns	Sowing date	Harvesting date	Yield/ ha (kg)	Basket Wt. (kg)	Price per basket (k)	Value of product	Cost of cultivation	Net income
Sessamum	11-4-77	3-7-77	242	24.6	160	1580.00	592.80	987.20
Rice	15-7-77	20-12-77	3616	21.0	10	1729.00	1143.61	585.39
						3309.00	1736.41	1572.59
Jute	21-4-77	18-8-77	540	-	-	2647.84	1687.00	960.84
Rice	13-7-77	30-11-77	3616	21.0	10	1729.00	1143.61	585.39
						4376.84	2830.61	1546.23
Rice	15-7-77	12-12-77	3977	21.0	10	1902.00	1143.61	758.39
Maize	23-12-77	7-4-78	2717	20.0	20	2173.60	1202.89	970.71
						4075.60	2346.50	1729.10
Rice	15-7-77	12-12-77	3977	21.0	10	1902.00	1143.61	758.39
Sorghum	2-1-78	25-5-78	1102	23.6	30	533.52)	708.80	750.88
			2000 (dry stalks)		0.46 per kg	926.25)		
						3361.77	1852.50	1509.27
Sessamum	11-4-77	3-7-77	212	24.6	160	1383.20	592.80	790.40
Rice (Seintalay)	15-7-77	20-12-77	4545	21.0	10	2173.60	1193.00	980.60
Sunflower	8-1-77	24-4-78	430	14.5	48	1422.72	755.82	666.90
						4979.51	2541.62	2437.90
Vegetable maize	18-5-77	14-7-77	7500 cobs		0.15/cob	2778.75	479.18	2299.57
Rice (Seintalay)	5-7-77	10-12-77	4545	21.0	10	2173.60	1193.00	980.60
Sunflower	14-1-78	30-4-78	359	14.5	48	1185.60	755.82	429.78
						6137.95	2428.00	3709.95
Vegetable maize	18-5-77	14-7-77	7500 cob		0.15/cob	2778.75	479.18	2299.57
Rice (Seintalay)	5-7-77	10-12-77	4545	21.0	10	2173.60	1193.00	980.60
Groundnut	13-1-78	23-4-78	701	11.4	50	3087.50	2074.80	1012.73
						8039.85	3746.98	4292.93

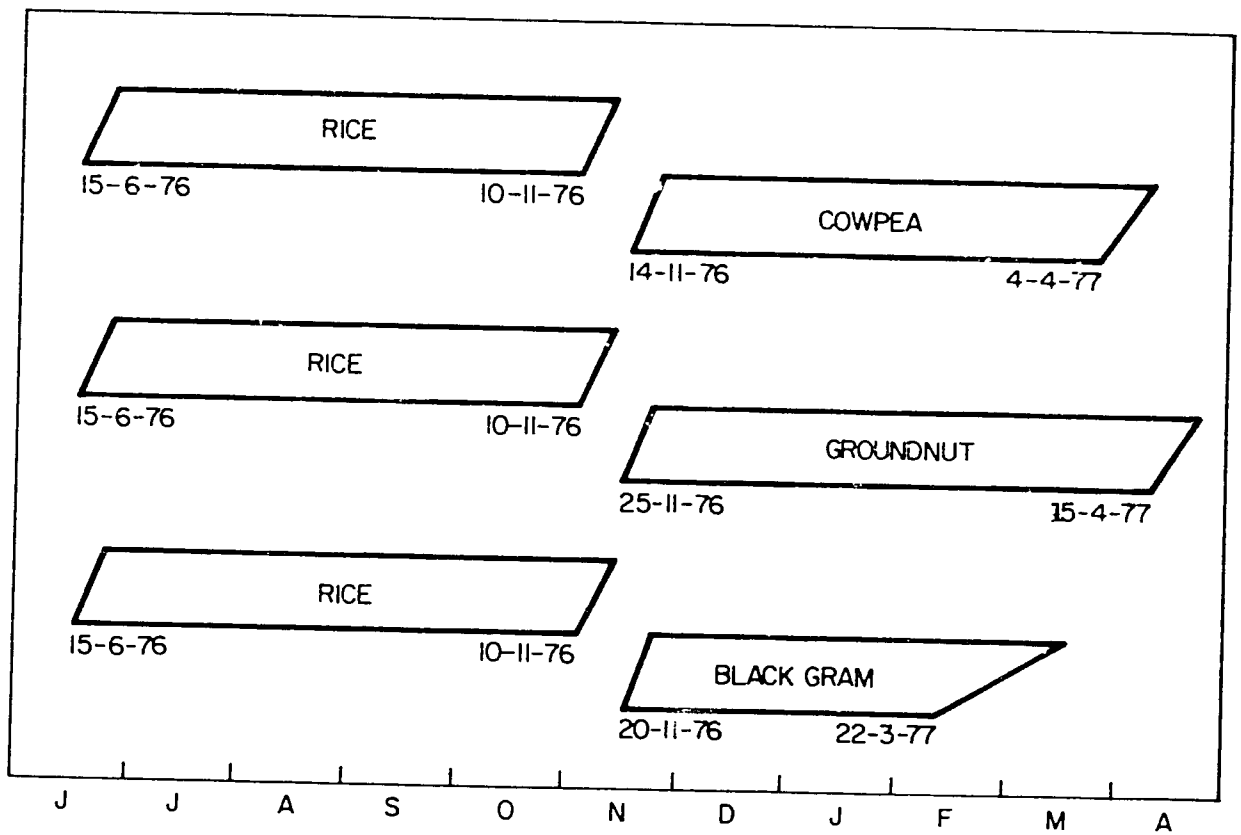

Fig. 1. Double cropping system with monsoon rice-grain legumes.

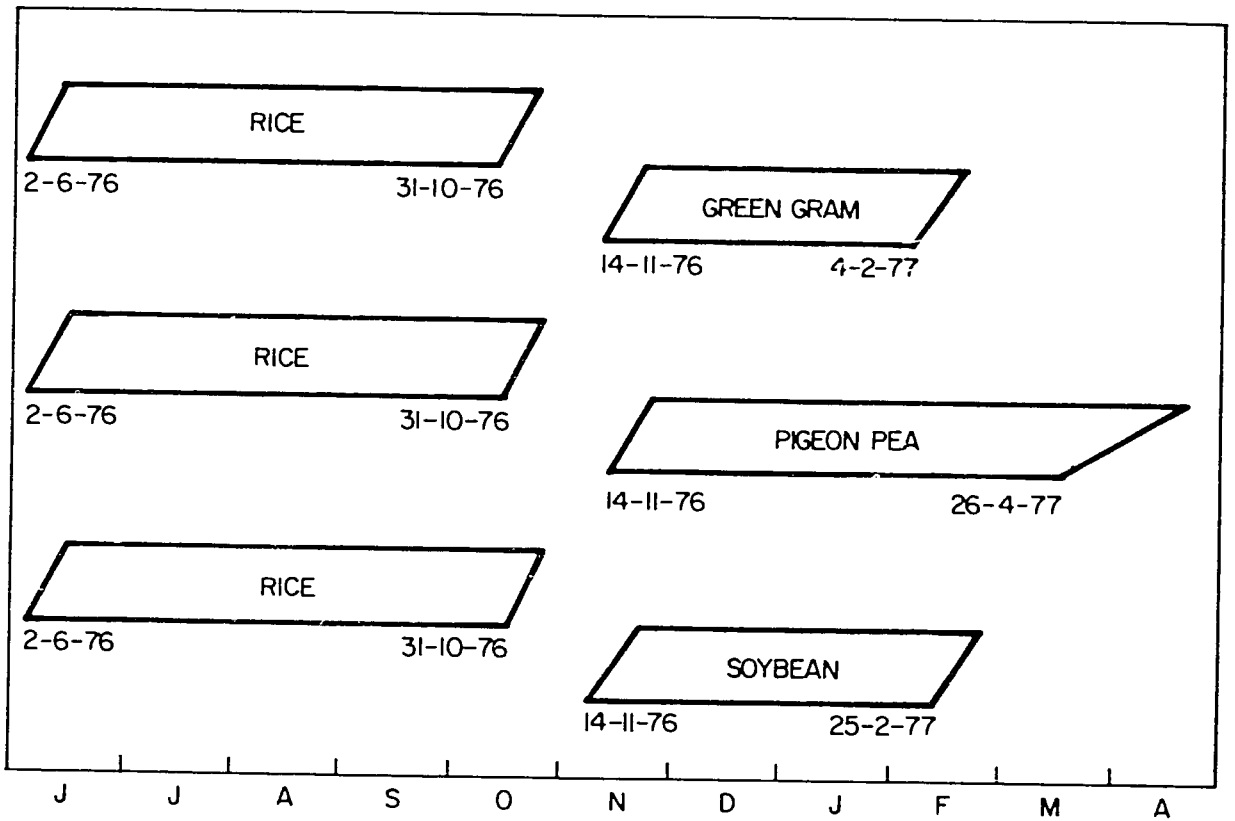
RICE
2-6-76
31-10-76
GREEN GRAM
14-11-76
4-2-77
RICE
2-6-76
31-10-76
PIGEON PEA
14-11-76
26-4-77
RICE
2-6-76
31-10-76
SOYBEAN
14-11-76
25-2-77
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Fig. 1. (Cont'd).

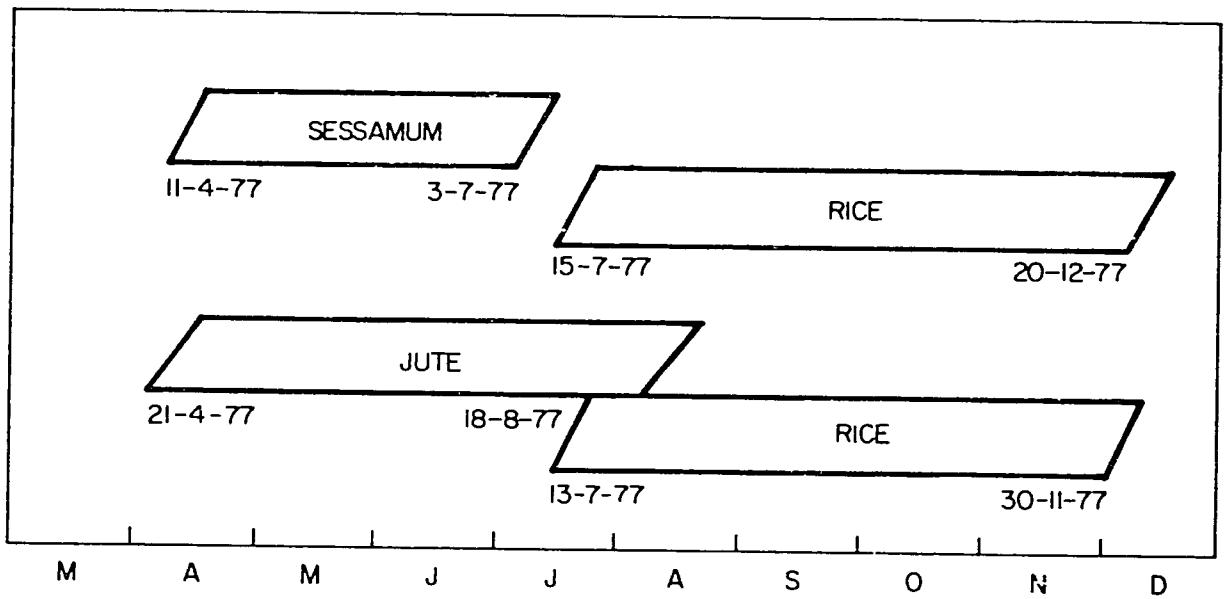

Fig. 2. Double cropping system with pre-monsoon crops-rice.

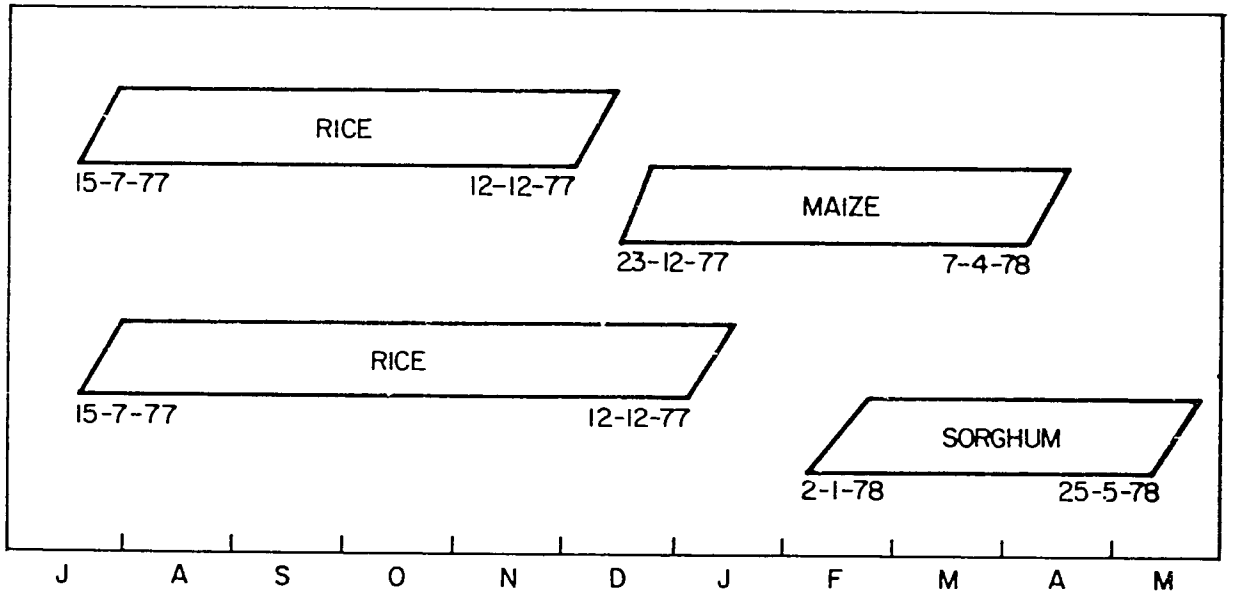

Fig. 3. Double cropping system with monsoon rice-course grain crops.

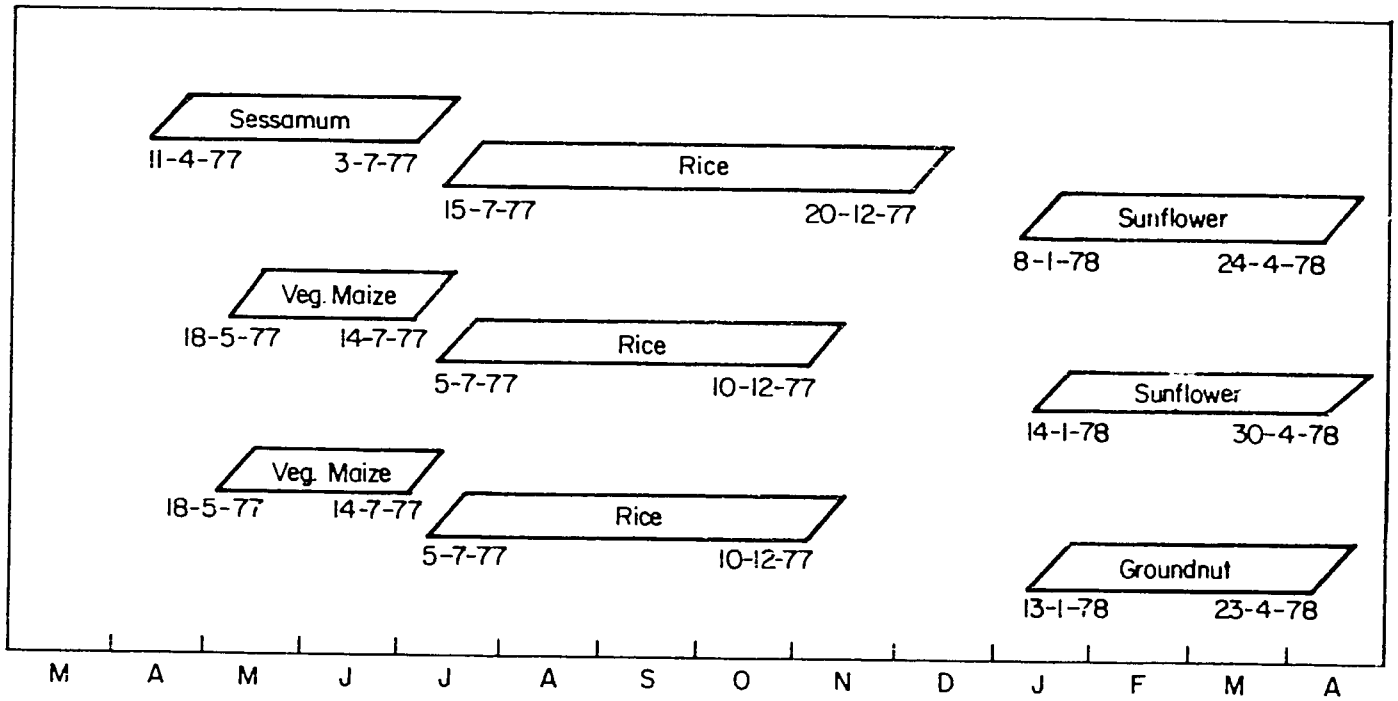

Fig. 4. Tripple cropping system with pre-monsoon crops-rice-oil crops.

CROPPING SYSTEMS PHILIPPINE OUTREACH SITE REPORT[1/]

INTRODUCTION

IRRI is currently operating two sites in collaboration with the Philippine Bureau of Plant Industry (BPI). One site is located near the northern end of the Central Luzon valley in Manaoag, Pangasinan. A second site is located in the muncipalities of Oton and Tigbauan, Iloilo, on the southern edge of the island of Panay. The location of the sites within the archipelago is shown in Figure 1. Table 1 contains salient characteristics of the two sites. Both sites are in their fourth and final year of full operation and therefore we have concentrated on getting an additional year of data on those patterns which have shown most promise over the past three years, and on refining component technology.

PANGASINAN

The proposed cropping patterns tested during CY 77/78[2/] (April 1977 - Feb. 78) are shown in Figure 2. Monthly rainfall totals are presented in Figure 3. The deviations in the CY 77/78 rainfall pattern relative to the long term pattern is striking. The number of proposed and actual cropping patterns grown during the year are presented in Table 2. The discussion which follows concentrates on the proposed DSR-TPR-UC pattern in which most deviations occurred.

Of 52 fields proposed for DSR-TPR-UC, only 16 completed the pattern. The rest deviated either to DSR-UC or DSR-TPR-Fallow patterns. Some of the reasons for the deviations were 1) late seeding of first crop (DSR) because farmer-cooperators waited for rains in late May before starting land preparation, 2) lack of access to the field by the farmer-cooperator at the time land preparation was required for the second rice crop because intervening fields contained crops in advanced stage of development, 3) poor germination of rice seeds distributed for the second crop, 4) labor competition with other farm operations and/or cottage industries, and 5) high risk of water shortage for the second rice crop. Thirty-three percent of the proposed R-R-UC, 70% of the GC-R-UC and 89% of the R-R-R patterns were completed as designed. Table 3 shows that thirteen of 24 farmers who planted DSR on May 31 or earlier grew full DSR-TPR-UC patterns, whereas only 3 of the 24 farmers who planted June 1 or later grew the full pattern as proposed.

[1/] This report contains a summary of CY 77/78 site results (Gines et al, 1978; Magbanua et al, 1978) and 1978 workshop discussions.

[2/] Explanations of the abbreviations used in this report are given in Appendix I.

As expected, time of DSR planting affected not only to the yield of the DSR crop (Table 4) but also the performance of the following TPR and upland crops (Fig. 4, Table 5).

It was observed that most farmer-cooperators waited until rains fell to prepare DSR fields even though a few farmers did plant earlier and experimental DSR treatments had also been planted earlier (Fig. 5). It is well recognized that water drastically reduces the draft power requirement for primary tillage. In tests made early this year, fields which had been flush-irrigated prior to land preparation showed much lower penetration resistance than comparable unirrigated fields. At 220 psi pressure, penetrometers would penetrate to an average depth of 19.9 cm in flush-irrigated fields, but to an average of only 3.9 cm on unirrigated fields. Farmers could plow flush-irrigated fields using a single animal; however, on dry fields, a rotovator was required for land preparation. The rotovator was difficult to manuever and many tines were broken. Moreover, with respect to clod size and consistency, unirrigated rotovated fields were much inferior to flush-irrigated animal-plowed fields. Even if mechanical tillage equipment is available, dry fields will still favor delays until rainfall wets the soil and reduces the power requirement.

The Green corn-TPR-UC pattern was assigned only to fields along the irrigation canal because these fields are well-drained and therefore green corn has a higher survival rate if rains come earlier than expected. The average performance of the pattern grown on this land was generally satisfactory, but crops were lost in two low-lying fields. Marketable ears averaged 25,000/ha for the green corn and TPR yields were about 3.5 t/ha on average. Where mungbeans were grown after rice, yields exceeded 1000 kg/ha. Yields were frequently over 1.4 t/ha. Application of insecticides in rather small doses, as recommended by the entomology section, has demonstrably increased mungbean yields (600 to 1600 kg/ha) compared to fields under farmer management at the start of the project (200 kg/ha).

The relative yields of UC are presented in Table 6 by water table sector and pattern group. The major yield differences were between patterns with early planted upland crops (i.e., R-UC + GC-R-UC) and patterns with late planted upland crops (R-R-UC). A water table effect is not apparent.

Several land-related factors have been found to alter crop yield levels, principally for second and third crops in the patterns. Heavy soil texture, presence of a shallow water table, and waterway positions have all been found to increase the yield of second rice crops. As shown in Table 7, partial irrigation clearly increased yields of second rice crops and perhaps late planted first rice crops (R-UC + GC-R-UC). Several of the other land-related factors affect the number of flooded days per crop, thereby indirectly influencing yields, but these land-related factors apparently have other influences on crop yields apart from maintaining standing water.

Costs and returns of different pattern groups in rainfed and partially irrigated fields under shallow and deep water table regimes are summarized in Table 8. A critical interpretation of the results cannot be made without considering other factors such as farmers' resources which affect date of planting, rates of material inputs and intensity of field operations. For

example, compared to farmers' current expenditures on existing patterns, material input costs for introduced patterns were often higher by a factor of 3 to 5. Pre-harvest labor inputs for introduced patterns were approximately double labor inputs on existing patterns. Despite these substantially higher labor and material inputs, introduced patterns were generally more profitable than existing patterns. Furthermore, the most profitable introduced patterns were competitive in terms of returns to cash and labor. Two points are suggested by these high labor and material input costs: (1) The introduced patterns will be very costly for farmers to adopt on a large scale if at all, and (2) the input level used in the introduced patterns may exceed the economic optimum levels, considering the farmer's cost of capital, opportunity cost of labor and risk. The second point has implications for further research.

Pattern testing in Crop Year 78/79. Proposed patterns for CY 78/79 are described in Fig. 6. During this current crop year we have emphasized designing and testing cropping patterns for the deep water table sector of Manaoag. The shallow-water table sector has been de-emphasized with the exception of a series of fields within two farmer irrigation groups under the Central Luzon Ground-water Irrigation Project Pump No. 2 command area. Pump No. 2 has a designed command area of approximately 50 hectares which has been divided into 5 rotational farmer irrigator groups. We have concentrated about 20 test fields in two adjacent rotational units of the command area. To date results have been mixed, mainly because irrigation water has not been reliable.

Component technology research in this final year has focused on problems detected in the patterns tested in previous years. It is necessary to obtain solutions to major production problems such as weed control in dry-seeded rice and to improve the efficiency of material inputs.

ILOILO

The proposed distribution of cropping patterns in Iloilo for crop year 77/78 is presented in Table 9. The monthly rainfall distributions for Iloilo (long term, CY 76-77 and CY 77-78) are presented in Fig. 7. Proposed and shifted first and second crops are presented in Tables 10 and 11, respectively. Because of the somewhat heavy early rains most farmers shifted from a green corn crop to a wet-seeded or transplanted rice crop. Of the 8 fields proposed for DSR, 7 fields were actually planted and 6 of these 7 were rated successful. Seventy-two percent of the first crops were established as WSR. Most farmers chose to wet seed so that only 20 fields were transplanted under a farmers' WSR/TPR options.

It is apparent that landscape position is an important factor that influences the performance of cropping patterns in the rainfed area of the Iloilo site (Table 12). Landscape position also influenced the date of first crop establishment, the number of flooded days on the first rice crop, and the last date on which the fields contained standing water (Table 13). Two rice crops could be successfully grown only on lower landscape positions, and even then yields were depressed. Upland crop yields appeared less affected by landscape position. Because of the early dry conditions, third crops were not attempted in any rainfed fields, although 6 farmer-cooperators produced ratoon crops averaging 0.8 t/ha prior to seeding UC.

The economic aspects of second rice TPR and WSR and ratoon production are presented in Table 14, by landscape position. In CY 77/78 ratooning was an attractive alternative to either WSR or TPR especially in the higher landscape positions. Average material and pre-harvest labor costs of failed and successful second crops are presented in Table 15. Apart from the rice ratoon, cowpeas and sorghum absorbed the least cash and labor inputs prior to harvest and therefore would result in the least loss in investment should the crop fail. A cost and return summary of cropping pattern groups is presented in Table 16 by landscape position. Because the effect of partial irrigation has not been removed, clear comparisons of rice-rice patterns cannot be made across landscape positions. However, ignoring the one partially irrigated observation on the plain, there was little difference in net returns for R-UC patterns across landscape positions. The Rice-UC patterns had higher net returns from Rice-Fallow patterns.

Pattern testing in Crop Year 78/79. The proposed cropping patterns for Iloilo 1978/79 are presented in Table 17. Upland crops will be limited to mungbean, sorghum and cowpea. To examine the suitability of ratooning more thoroughly, 3 patterns which include ratooned rice have been planned.

Component technology trials are being conducted to refine critical cultural technique and input level recommendations for crops in each of the patterns. Increased emphasis has been given to component technology for DSR.

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Appendix I

CY - crop year. The crop year is assumed to start late in the normal fallow period. For the Iloilo and Pangasinan sites, the CY starts on April 1 and ends on March 31.

TPR - transplanted rice. Rice transplanted using traditional methods or flooded and usually puddled soils.

WSR - wet-seeded rice. Rice broadcast on flooded and usually puddled soils.

DSR - dry-seeded rice. Rice broadcast or placed in rows (drilled) in unflooded soil. The soil water condition may range from near-saturation to parched.

UC - upland crops. The UC designation is used to indicate upland crops grown after rice. These crops include mungbean, cowpea, peanut, sweet potato, sorghum, bush sitao and soybean.

X - upland crop or fallow period. The designation is used when patterns are combined and upland crops are not considered important for the comparisons of interest, usually between the rice crops. E.g. WSR-TPR-MG and WSR-TPR-F are WSR-TPR-X patterns.

GC - green corn. A corn crop grown preceding rice and harvested before ripening.

R - rice. This designation is used to indicate rice crops which fall in the same position within the pattern, regardless of establishment method. E.g. WSR-TPR-MG and DSR-TPR-CP are R-R-UC patterns.

_ - underscore. An underscore is used to indicate the crop within a pattern for which data is being cited, or to which reference is being made.

Table 1. Several important characteristics of the Iloilo and Pangasinan outreach sites.

	Iloilo	Pangasinan
Rainfall	5-6 wet months 3-4 dry months	3-4 wet months 5-6 dry months
Topography	(a) Rainfed inter-hill miniplains and colluvial slopes, (b) flat plains of a river terrace system.	Flat plains of a river terrace system and old levees.
Dominant soils	Pelluderts, Eutropepts and Tropfluvents	Eutropept
Dominant Surface soil texture	Clay and silty clay	Clay loam
Soil reaction	Moderately to slightly acid	Neutral to slightly alkaline
Average farm size	1.2 ha	0.9 ha
Dominant power source	Carabao	Carabao and bullocks
Major patterns at start of the project	Rice-fallow Rice-UC	Rice-fallow Rice-UC GC-Rice-UC

Table 2. Number of proposed and actual cropping pattern fields at the CS outreach site, Manaoag, Pangasinan, CY 77/78.

	Pattern Groups		
	R-R-UC	GC-R-UC	R-R-R
Shallow water table			
Proposed	31	-	9
Actual	13	-	8
Deviated	18	-	1
Deep-water table			
Proposed	21	17	-
Actual	3	14	-
Deviated	18	3	-

Table 3. Breakdown of 48 proposed DSR-TPR-UC cropping pattern fields as affected by time of DSR seeding, Manaoag, Pangasinan. CY 77/78.

Time of seeding	Number of fields		
	DSR-TPR-UC	DSR-TPR-F	DSR-UC
Before May 12	1	-	-
May 13-21	3	1	1
22-31	9	5	4
Jun 1-7	2	9	3
8-15	1	1	4
Beyond June 16	-	-	4
Total	16	16	16

Table 4. Mean rice yields (t/ha) of 48 DSR CP fields and 8 experimental plots as affected by time of seeding, Manaoag, Pangasinan, CY 77/78.

Time of Seeding	DSR-TPR-UC	DSR-TPR-F	DSR-UC	Experimental[1/]	Mean
Before May 12	6.5 (1)	-	-	4.8 (5)	5.1
13-21	5.5 (3)	4.4 (1)	4.4 (1)	4.5 (3)	4.9
22-31	5.0 (9)	5.2 (5)	3.7 (4)	-	4.8
June 1-7	2.7 (2)	4.5 (9)	3.3 (3)	-	4.0
8-15	4.9 (1)	5.1 (1)	3.6 (4)	-	4.1
Beyond June 16	-	-	4.2 (4)	-	4.2

[1/] Average yields from a research-managed experiment in which plots were planted at 5-day intervals. Mean of 4 replications.

( ) No. of observations

Table 5. Mean relative yields of upland crops in the DSR-TPR-UC fields as affected by time of seeding first rice, Manaoag, Pangasinan, CY 77/78.

Time of Seeding DSR	No. of plots	Relative yield (%)[1/]
Before May 12	1	61
13-21	3	40
22-31	9	43
June 1-7	2	0
8-15	1	0

[1/] The bases for computing this relative yields were 0.8 t/ha for mungbean, 0.6 t/ha for cowpeas/bush sitao and 2.4 t/ha for sorghum. These bases were obtained from variety trials conducted at Manaoag during the same season.

Table 6. Mean relative yields[a/] of upland crops by water table regimes, Manaoag, Pangasinan, CY 77/78.

Water table regime	R-R-UC	R-UC + GC-R-UC
Shallow		
Mung	27 (3)[b]	123 (8)
Cowpea + Bush Sitao	21 (7)[c]	94 (5)
Sorghum	62 (3)	74 (5)
Deep		
Mung	36 (2)	127 (15)
Cowpea + Bush Sitao	0 (1)	157 (8)
Sorghum	-	78 (9)

[a/] The yield bases are given in the footnote of Table 5.
[b/] Includes 1 failure
[c/] Includes 4 failures
( ) No. of observations

Table 7. Mean rice yields (t/ha) and FSD's of pattern groups by irrigation class, Manaoag, Pangasinan, CY 77/78.

	R-R-X	R-R-X	GC-R-UC+R-UC
Irrigation Class I[a/]			
Yield (t/ha)	5.0	1.8	3.6
FSD[b/]	32	9	35
No. of observations	25	25	26
Irrigation Class II			
Yield (t/ha)	4.9	3.3	4.0
FSD	30	14	37
No. of observations	8	8	13

a/ I - Rainfed and irrigated not more than 1-1/2 months beyond normal end of rainy season

II - Rainfed and irrigated more than 1-1/2 months beyond normal end of rainy season but less than 9 months in total

b/ FSD - number of flooded status days.

Table 8. Comparison of costs and returns of different pattern groups in rainfed and partially irrigated fields under shallow and deep water table regimes, Cropping Pattern Trials, Manaoag, Pangasinan CY 1977/78

Water table	Irrigation classes	Pattern groups	No. of plots	Requirements (₱/ha)				Returns ₱/ha			
				Material costs	Labor costs		Total variable costs	Gross	Net	To Labor 1/	To Cost 2/
					Pre-harvest	Harvest & Threshing					
Shallow	Rainfed	R-R-UC 3/	3	3143	1912	1821	6876	9102	2226	2.4	2.9
		R-UC 4/	13	2231	1666	1410	5307	7474	2167	2.2	3.4
		R-R	7	2224	1950	1286	5460	6432	972	1.7	2.9
Shallow	Partially irrigated	R-R-UC 5/	10	3122	1934	2967	7123	10582	3459	2.8	3.4
		R-UC 6/	2	1812	938	1562	4312	8544	4232	4.4	4.7
		R-R	6	2592	1592	2047	6231	9236	3005	3.0	3.6
Deep	Rainfed	R-R-UC 3/	3	2980	1136	1999	6124	10432	4308	5.1	3.5
		R-UC 4/	15	738	1263	4048	6780	6780	2732	4.0	3.3
		R-R	4	2315	1380	1600	5295	7997	2702	4.0	3.4
Deep	Partially irrigated	GC-R-UC 5/	14	2926	968	1682	5576	9833	4257	4.4	3.4
		R-UC 6/	2	1886	283	2373	4542	9951	5409	8.0	5.3
		R-R	5	2149	1097	1384	4630	6925	2295	3.3	3.2

1/ $\frac{\text{Value of Product (₱/ha)} - \text{Value of Material Inputs (₱/ha)}}{\text{Total labor (mhr/ha)}}$

2/ $\frac{\text{Value of Product (₱/ha)}}{\text{Value of Material Inputs (₱/ha)}}$

3/ Upland crop include mungbean, cowpea, bush sitao

4/ Upland crop include mungbean (60%), sorghum (27%), cowpea (13%)

5/ Upland crop include mungbean (36%), cowpea (36%), sorghum (28%).

6/ Upland crop include mungbean, sorghum

Table 9. Distribution of the proposed cropping patterns, by landscape position, for the 1977-78 crop year, Iloilo.

Cropping patterns	Number of Fields per Landscape Position				
	Plain	Plateau	Sideslope	Bottomland	Total
Rice-Rice-Upland Crops					
DSR-WSR-(M, CP)	4	2	2	-	8
WSR-TPR-(M, CP)	6	2	2	6	16
WSR-WSR-(M, CP)	-	-	-	4	4
Rice-Upland Crops					
(WSR,TPR)-S	2	3	3	-	8
(WSR,TPR)-P	2	3	3	-	8
(WSR,TPR)-M	2	3	3	-	8
(WSR,TPR)-CP	2	3	3	-	8
(WSR,TPR)-SP	2	3	3	-	8
(WSR,TPR)-SB	2	3	3	-	8
G. Corn-Rice-Upland Crops					
GC-(WSR, TPR)-M	2	5	3	-	10
GC-(WSR, TPR)-CP	2	5	3	-	10
Total number of fields					96

Table 10. Summary of the proposed and actually grown first crops, by landscape position. Iloilo 1977-78 crop year.

Pattern component[1/]	Number of Fields per Landscape Position				
	Bottomland	Plain	Plateau	Sideslope	Total
GC					
Actual	0	0	0	0	0
Proposed	0	4	10	6	20
DSR					
Actual	0	1	4	2	7
Proposed	0	4	2	2	8
WSR					
Actual	10	25	22	12	69
Proposed	10	18	20	20	68
TPR					
Actual	0	2	4	14	20
Proposed	0	0	0	0	0

[1/] GC = Green corn; DSR = dry-seeded rice; WSR = wet-seeded rice; TPR = transplanted rice.

Table 11. Distribution of proposed, shifted, unplanted, and actual crop components of rainfed cropping patterns during the second crop, by landscape position. Iloilo 1977-78 crop year.

Landscape position	Number of fields							
	Proposed		Shifted		Unplanted		Actual	
	Rice	UC[a/]	Rice	UC	Rice	UC	Rice	UC
Bottomland	8	-	-	-	-	-	8	-
Plain	16	9	2UC	4R	2	2	16	5
Plateau	15	14	11UC	2R	2	3	4	20
Sideslope	9	17	9UC	1R	-	4	1	21
Total	48	40	22	7	4	9	29	46

[a/] Upland crops

Table 12. Summary of performance of different rainfed pattern groups by landscape position. Iloilo 1977-78 crop year.

Landscape position	Pattern group	No. of fields	Yield	
			Crop 1 (t/ha)	Crop 2 (t/ha or %)[a]
Sideslope	Rice-Rice	1	5.2	0.8
	Rice-UC	21	5.0	48 (4)[b]
	Rice	4	3.6	-
Plateau	Rice-Rice	3	5.7	0.5
	Rice-UC	22	5.3	32 (10)
	Rice	5	4.3	-
Plain	Rice-Rice	15	5.5	1.8 (7)
	Rice-UC	5	4.6	52 (1)
	Rice	4	4.9	-
Bottomland	Rice-Rice	8	6.1	2.1 (2)

[a] Yields of upland crops are on a relative yield basis (Mungbean - 1.2t/ha = 100%; Cowpea - 1.7t/ha = 100%; Sorghum - 8.3t/ha = 100% and Peanut - 2.8t/ha = 100%. These were the highest yields obtained in any of the cropping pattern fields and are believed to reflect the maximum performance obtainable by farmer-cooperators.

[b] Integers in the parentheses represent the numbers of field that failed. The failures were included as zero yield in the computation of means.

Table 13. Effect of landscape position on three rainfed field characteristics governed by water regimes.

Landscape position	Average week of first crop establishment	Average number of flooded days on first rice crop	Average week during which the field last held standing water
	Week No.	Days	Week No.
Bottomland	25	78	46
Plain	27	76	45
Plateau	27	76	41
Sideslope	28	61	41

Table 14. Cost and returns (₱/ha) of second rice crop by landscape position. Iloilo 1977-78 crop year.

Landscape position	Number of plots	Yield (t/ha)	Material cost	Pre-harvest	Harvest/ thresh	Total variable cost	Total returns	Return over variable cost
Sidelope & plateau								
TPR	1 (0)	0.00	659	824	-	1483	0	-1483
WSR	2 (2)	1.01	752	334	178	1264	1072	-192
Ratoon	5 (0)	0.91	26	6	101	193	4964	771
Plain								
TPR	9 (3)	2.42	752	671	428	1851	2569	718
WSR	9 (0)	1.21	764	551	214	1569	1285	-284
Bottomland								
TPR	5 (1)	2.29	693	666	405	1764	2429	665
WSR	4 (1)	2.24	783	437	396	1616	2373	757
Ratoon	1 (0)	0.64	-	-	113	113	677	564

( ) no. of plots with partial irrigation

Table 15. Average material and pre-harvest labor costs of failed and successful second crops. Iloilo 1977-78 crop year.

Crop	No. of fields	Material Cost	Pre-harvest Labor Cost	Total Variable Cost
Failed				
WSR	8	652 (73)[a]	405 (69)	1057 (71)
TPR	2	696 (95)	717 (97)	1413 (96)
Mungbeans	5	794 (81)	236 (119)	1030 (87)
Cowpeas	5	388 (55)	439 (211)	827 (90)
Peanuts	2	1003 (68)	651 (119)	1654 (81)
Sorghum	1	436 (75)	224 (111)	660 (85)
Successful				
WSR	7	898	591	1489
TPR	13	731	740	1471
Ratoon rice	6	22	5	27
Mungbeans	11	984	198	1182
Cowpeas	12	709	208	917
Peanuts	2	1481	549	2030
Sorghum	9	578	202	780

[a] Percent of average input applied to a non-failed crop

Table 15. Costs and returns (₱/ha) summary of cropping pattern groups by landscape position. Iloilo 1977-78 crop year.

Landscape position	Pattern group	No. of fields	Material cost	Labor cost		Total Variable cost	Total Returns	Net Returns
				Pre-harvest	Harvest/ Thresh			
Sideslope	Rice-Rice	3 (2)	1094	882	1131	3107	6783	3676
	Rice-UC	21	1366	1007	1154	3527	6924	3397
	Rice-Fallow	4	482	453	503	1438	3070	1582
Plateau	Rice-Rice	3	1120	868	944	2932	5666	2734
	Rice-UC	22 1/	1404	777	1139	3320	6831	3511
	Rice-Fallow	5	630	475	586	1691	3513	1822
Plain	Rice-Rice	18 (3)	1452	994	1145	3591	6868	3277
	Rice-UC	6 (1)	1319	565	1007	2891	6044	3153
	Rice-Fallow	4	589	521	674	1784	4041	2257
Bottomland	Rice-Rice	10 (2)	1306	849	1295	3450	7768	4318

1/ Includes yields of 2 ratoon crops. Ignoring the ratoon crop, the net return of this pattern was ₱3285/ha.

( ) number of observations receiving partial irrigation.

Table 17. Proposed cropping patterns. Iloilo 1978-79 crop year.

Cropping patterns	Landscape position			Total
	Bottomland	Plain/plateau	Sideslope	
I. Rice-Upland crop				
WSR-UC	-	3	3	6
TPR-UC	-	3	3	6
II. Rice-Rice-Upland crops				
DSR-WSR-UC	-	3	3	6
DSR-TPR-UC	-	3	3	6
WSR-WSR-UC	3	3	-	6
WSR-TPR-UC	3	3	-	6
DSR-RAT-UC	-	3	3	6
WSR-RAT-UC	3	3	-	6
TPR-RAT-UC	3	3	-	6
III. Corn-Rice-Upland crops				
GC-WSR-UC	-	3	3	6
GC-TPR-UC	-	3	3	6
TOTAL	12	33	21	66

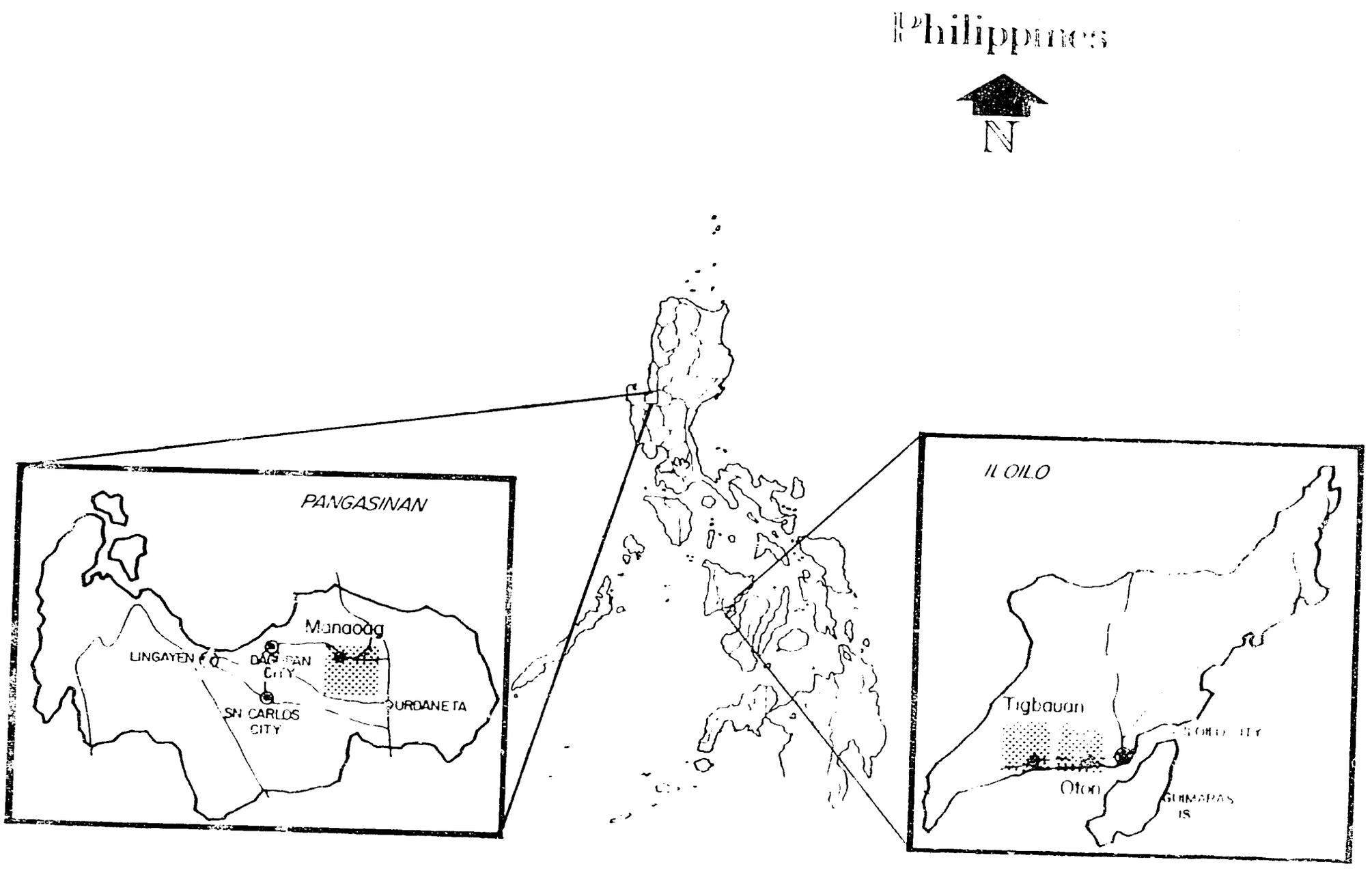

FIG. 1. LOCATIONS OF TWO RESEARCH SITES OF THE CROPPING SYSTEMS PROGRAM INTERNATIONAL RICE RESEARCH INSTITUTE.

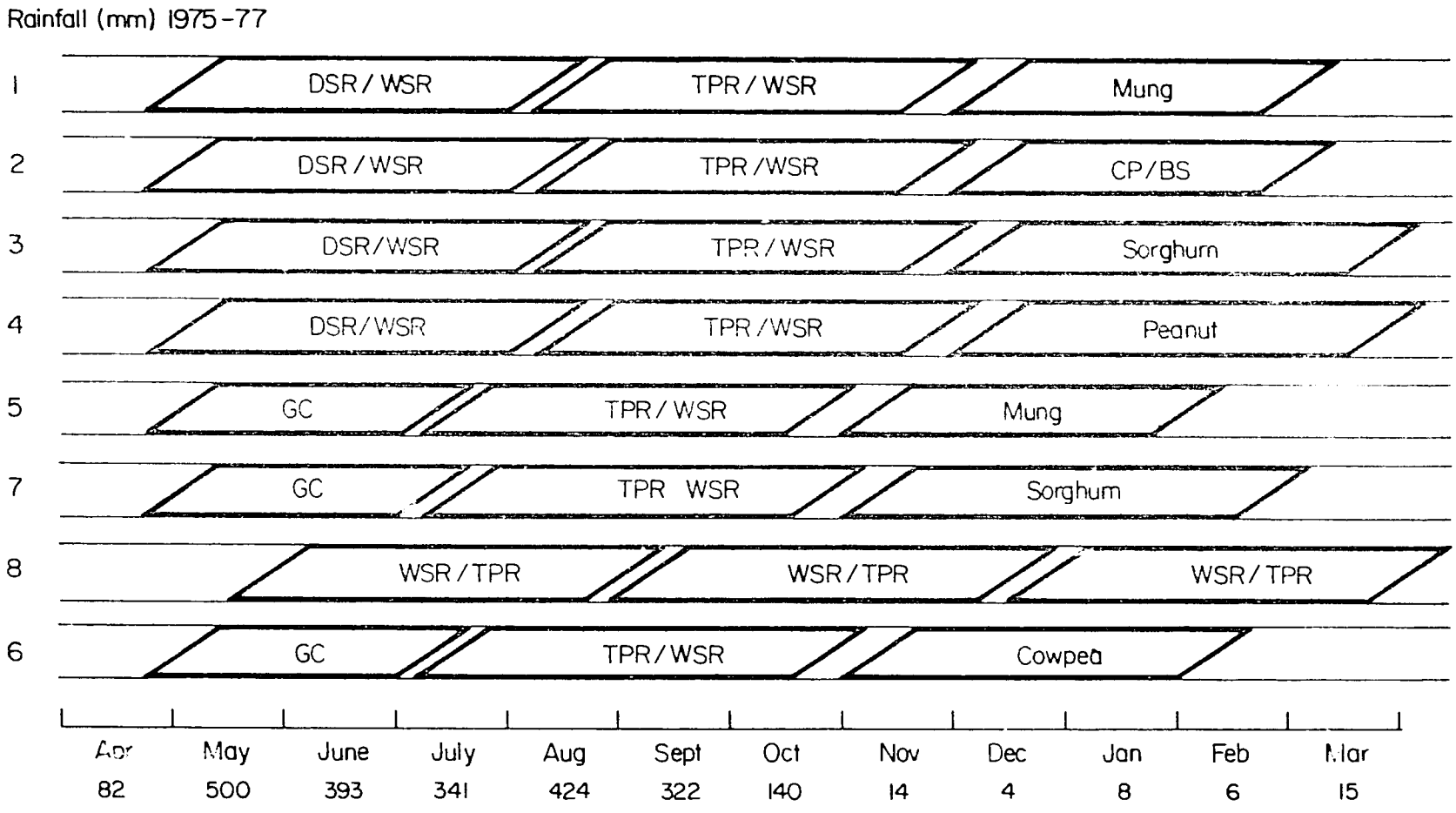

Figure 2. CY 1977-78 cropping patterns tested in Manaoag, Pangasinan

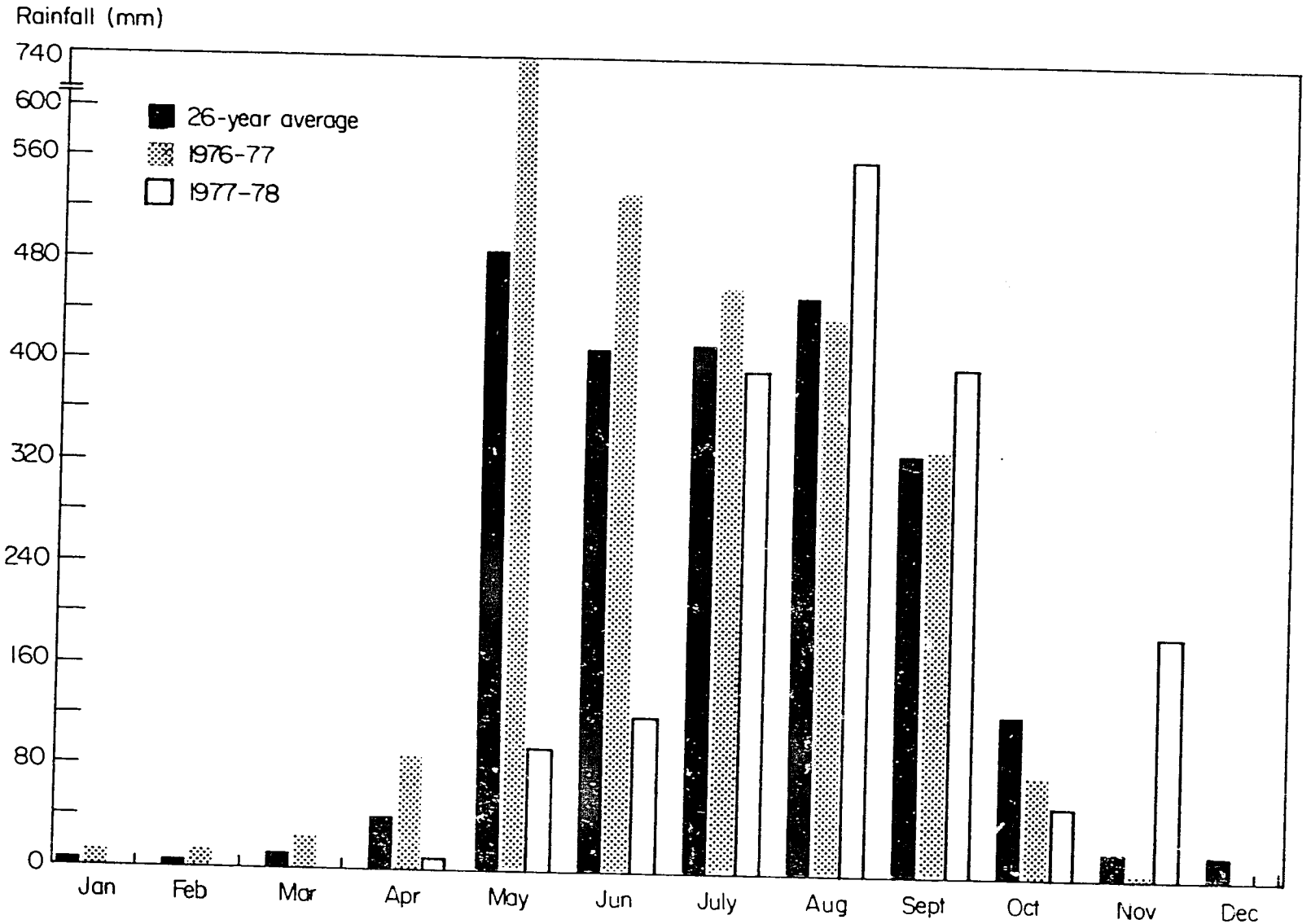

Figure 3. Distribution of rainfall by month for crop years 1976-77, 1977-78 for Manaoag and the 26-year average from Dagupan City, Pangasinan.

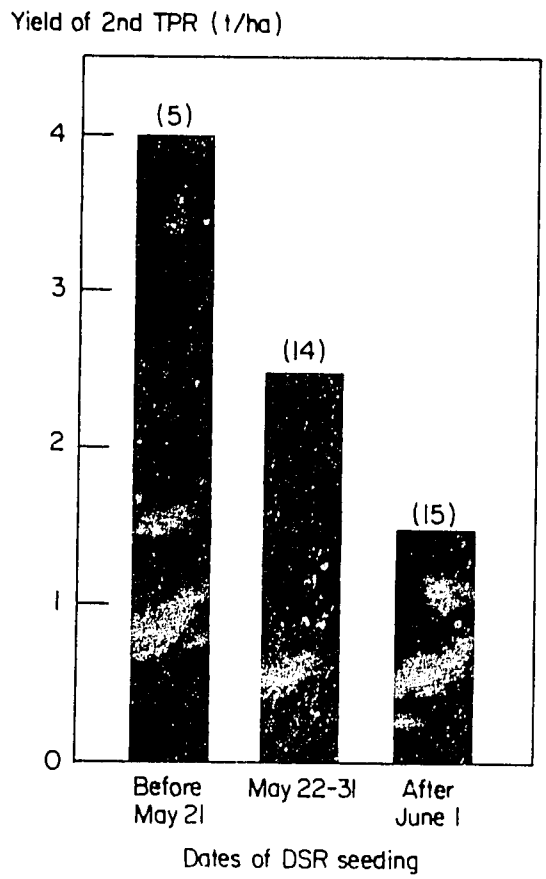

Figure 4. Mean yields from farmer-cooperators' second rice crop (TPR), as affected by date of seeding the first rice crop (DSR), Manaoag, Pangasinan, CY 77/78.

( ) Number of observations

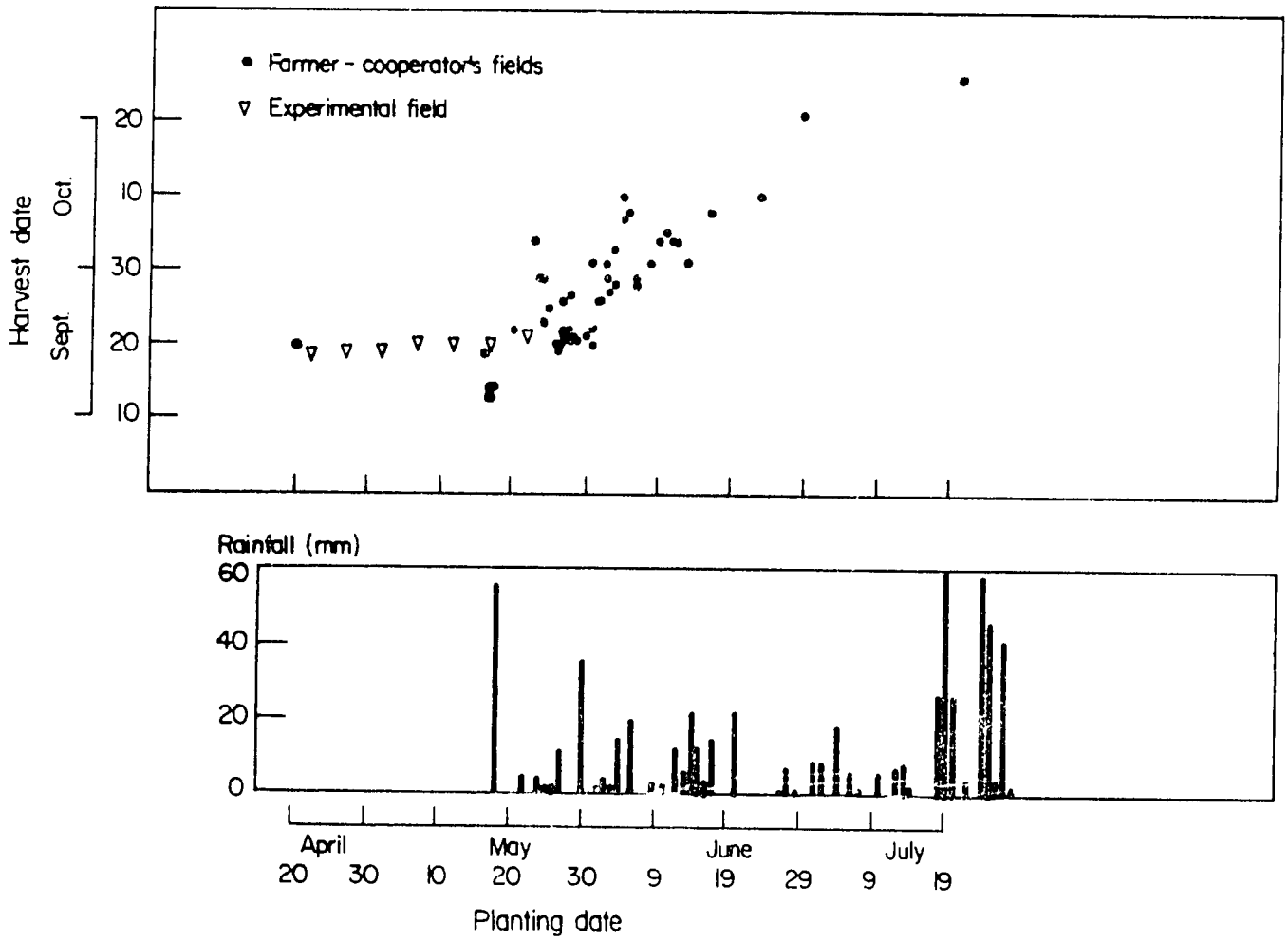

Figure 5. DSR planting date versus harvest date in farmer-cooperator and experimental fields (upper) vs. daily rainfall during the planting period (lower).

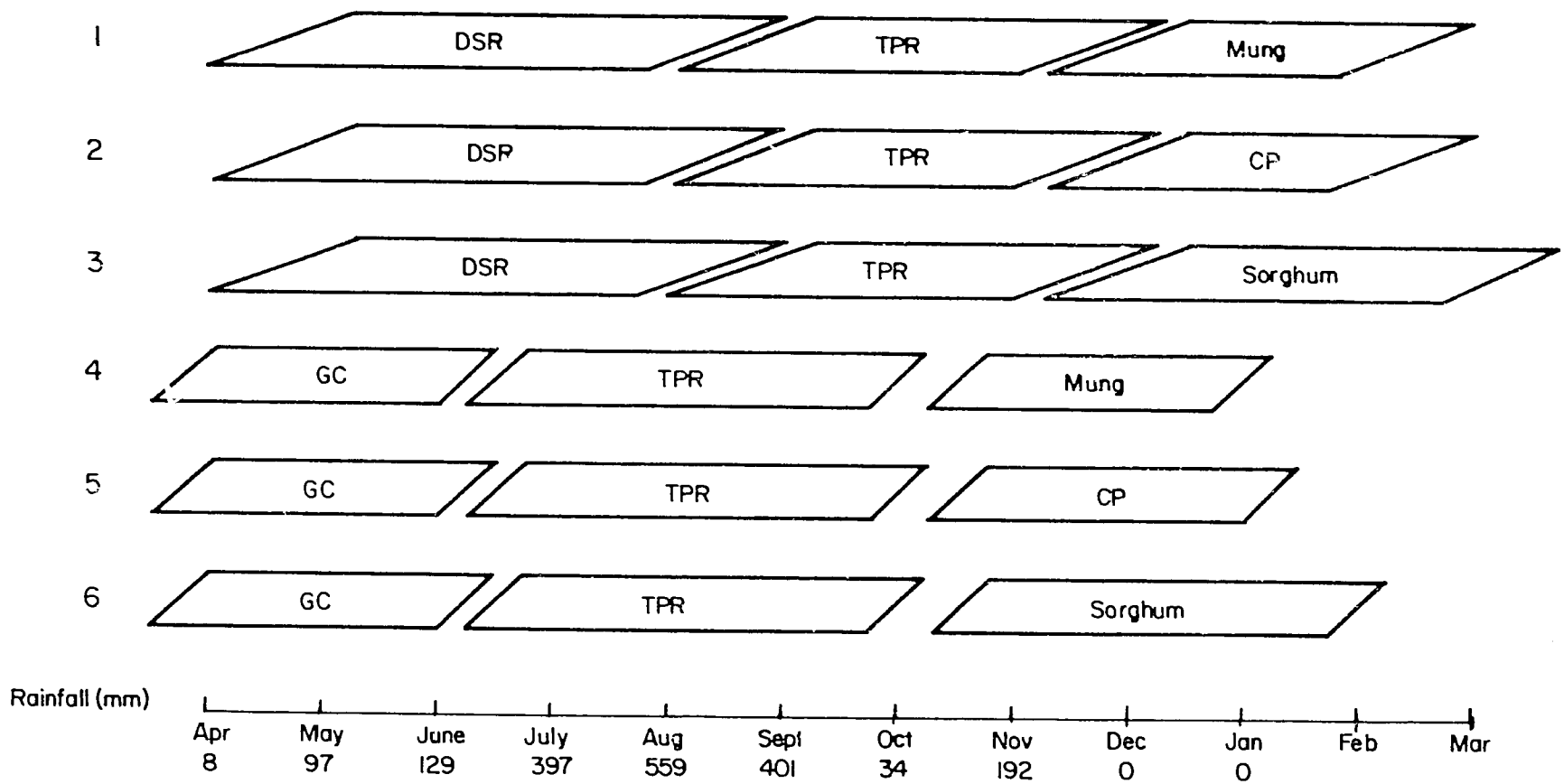

Figure 6. Proposed cropping patterns for Pangasinan, CY 1978-79.

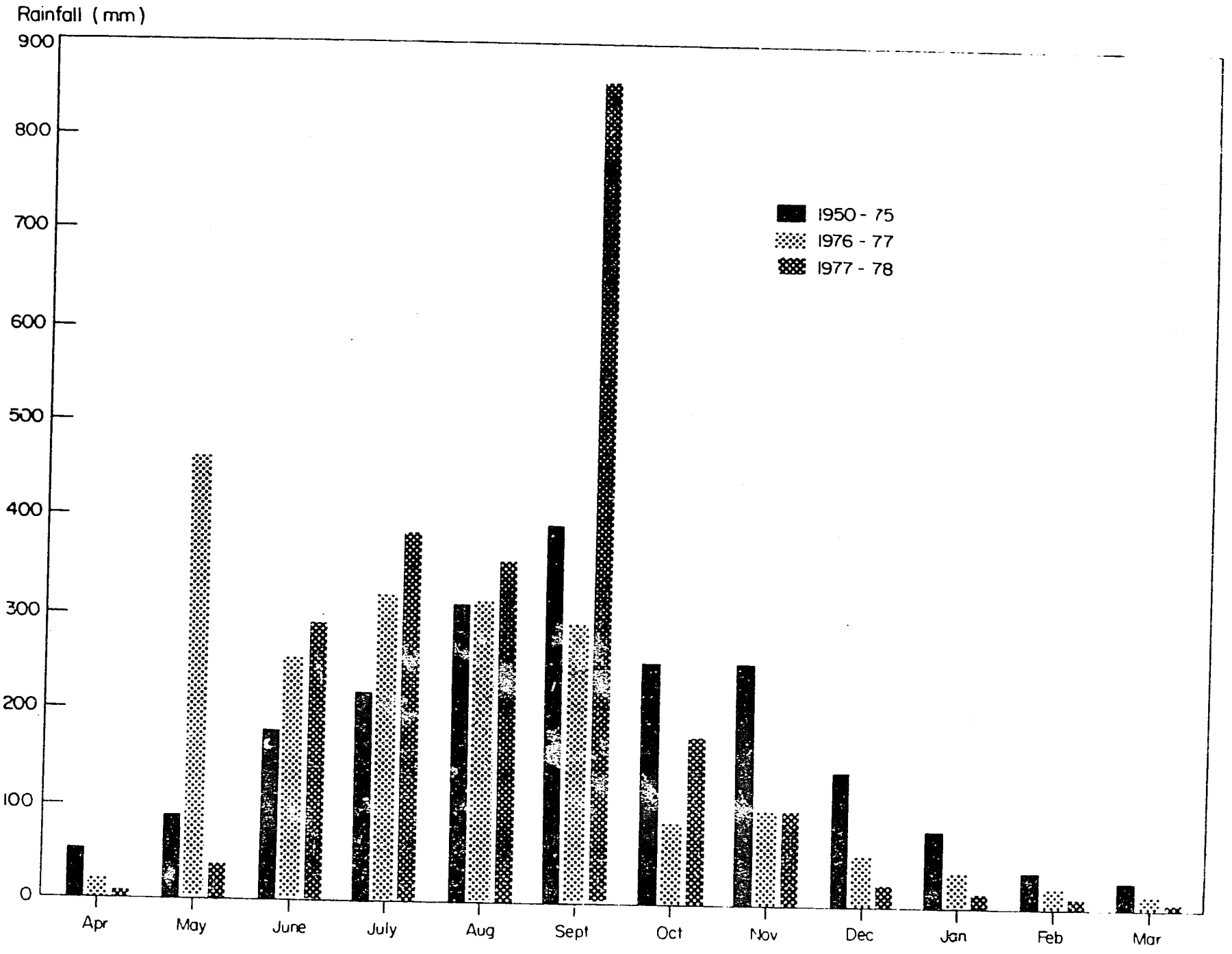

Figure 7. Comparison of 1977-78 monthly rainfall with the 1976-77 and the 25-year average.