APPENDIX A

ANALYTICAL FRAMEWORK

for

Identification and Assessment of Stage of Readiness for Diffusion to Farmers of Agricultural Technologies and Technology Systems in Selected African Countries

The analytical framework for the survey is structured around the following basic sets of elements critical to the identification and determination of stage of readiness for diffusion of appropriate agricultural technologies:

1) Agricultural
2) Institutional
3) Socioeconomic

Approximately one hundred critical agricultural, institutional and socioeconomic elements were identified and assessed in relation to three potentially appropriate technology sets (drought resistant crops, response farming, alley cropping) at a multidisciplinary planning meeting organized by the Academy. The insights and conclusions gained from that discussion, plus additional suggestions received later from meeting participants and others, served as the basis for developing the framework to be used for the survey.

The analytical framework, presented on the pages which follow, is organized into:

I. General guidelines (p. 4)

II. Identification Sheet (p. 5)

III. General Information (pp. 6-8)

IV. Relevant National, Regional, and International Institutions and Programs (pp. 9-11)

V. Agricultural Technology Assessment (pp. 12-13)

VI. Summary of Agricultural Technologies identified, by Stage of Readiness Category (pp. 14-16)

VII. Illustrative List of Agricultural, Institutional and Socioeconomic Factors to be Considered in Assessing Technologies (pp. 17-21)

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Agricultural Technology Identification and Assessment
Africa

I.

GENERAL GUIDELINES

A. Assessment and classification of technologies identified must ultimately be farmer-based--what farmers need; what they want; benefits to be derived; practical feasibility; management skills required; risk factors.

B. Both private and public sector institutions are to be considered with respect to technology generation, constraints to or facilitators of technology adoption, and actual or potential diffusion channels.

C. Classification of technologies for a given country is to be done on a country- and region-specific basis, although the technologies may not always be indigenous.

D. Time will not be sufficient to analyze all factors in depth. Therefore, in addition to making preliminary assessments based on available information, it is critically important that issues requiring additional study and analysis be identified.

E. A collection of plans, reports, documents, organizational charts and other information (referenced as appropriate on the data forms) relevant to the survey in each country is to be assembled for reference during final report preparation.

F. Factors such as time likely to be required to achieve significant farmer adoption and possibilities for incremental introduction of complex technologies or technology systems are to be considered in developing recommendations for improving diffusion.

G. The illustrative list of agricultural, institutional and socioeconomic factors to be considered in assessing technologies provides a "checklist" of elements to be considered in assessing the constraints relevant to each potentially appropriate technology identified.

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Africa

II.

IDENTIFICATION SHEET

Country: Date of Survey:

Survey Team:

Principal USAID Mission contact(s): (Name and position)

Principal Host Country Institution(s) and Staff Collaborating in Survey: (Institution, person, address)

In-country locations visited:

Survey Team Leader:

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Agricultural Technology Identification and Assessment
Africa

III.

GENERAL INFORMATION

(To be developed in the U.S. during pre-survey preparation stage, and checked in the field)

Country:

A. Population Data

1. Total population
2. Rural population
3. No. farm families
4. Rate of population growth
   a. Total
   b. Rural
5. Rural family size

B. Land Use (Indicate trends)

1. Total area
2. Area under cultivation
3. Range area
4. Forested area
5. Wasteland

C. National Agricultural Production (Indicate trends)

1. Principal crops
   a. Area
   b. Production
   c. Use
2. Livestock
   a. Class
   b. Numbers
   c. Use
3. Forest, including tree crops
   a. Area
   b. Production
   c. Use
4. Fish culture
   a. Area
   b. Production
   c. Use

5. Other
    a. Area
    b. Production
    c. Use

D. **Ecological zones** (attach map)
(For each ecological zone)

1. Rainfall
    a. Annual
    b. Distribution
    c. Variability
2. Temperatures
    a. Mean minimum and maximum by month
    b. Variability

E. **Land characteristics by ecological zone**

1. Topography
2. Soils

F. **Agricultural characteristics by ecological zone**
(Indicate trends as appropriate)

1. Area under cultivation
    a. Rainfed
    b. Irrigated
2. Farm size distribution
3. Principal crops
    a. Area
        - rainfed
        - irrigated
    b. Planting and harvest periods
    c. Yield (mean and range)
    d. Use
    e. Present and potential economic viability
    f. Major cropping patterns
    g. Impact of drought and pests
4. Principal livestock enterprises
    a. Class
    b. Production cycle
    c. Use
    d. Present and potential economic viability
    e. Crop/livestock interactions
5. Other agricultural enterprises
6. Major technologies introduced and widely adopted during last five to ten years
    a. Where adopted and extent of use
    b. Constraints to their adoption
    c. Time required to achieve significant adoption
    d. Persistence of use by farmers

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G. **Major constraints to agricultural development**

1. National
    a. Technological
    b. Institutional
    c. Socioeconomic

2. By ecological zone
    a. Technological
    b. Institutional
    c. Socioeconomic

H. **Information sources**

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Agricultural Technology Identification and Assessment
Africa

IV.

RELEVANT NATIONAL, REGIONAL AND INTERNATIONAL INSTITUTIONS AND PROGRAMS

(Provisional compilation to be made during pre-survey preparation stage for verification and amplification during survey)

Country:

A. **Agricultural Research Institutions/Programs**

1. National (public and private sector)

   a. Name
   b. Affiliation
   c. Location(s)
   d. Facilities
   e. Organizational structure
   f. Areas of research activity
   g. Relevance of research to small and medium farmers
   h. Scientific staff
      i. Name(s)
      ii. Position
      iii. Training and experience
   i. Research technician staff
   j. External donor support (source/amount/purpose)
   k. Method of determining research priorities
   l. Extent of on-farm research
   m. Linkages with other research institutions/programs
   n. Linkages with technology diffusion institutions/programs
   o. Linkages with input and service providers
   p. Major research contributions in last decade

2. Regional (public and private sector)

   a. Name
   b. Affiliation/funding source
   c. Date of establishment
   d. Ongoing or limited duration (estimated termination date in case of latter)
   e. Affiliations with national institutions/programs
   f. Location(s) in-country and elsewhere
   g. Facilities
   h. Areas of research activity

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i. Relevance of research to small and medium farmers in country
j. Scientific and technician staff
k. Method of determining research priorities
l. Extent of on-farm research
m. Linkages with other regional and international research institutions/programs
n. Linkages with technology diffusion institutions/programs
o. Linkages with agrosupport sector (inputs, services, markets)
p. Major research contributions in last decade relevant to small and medium farmers in country

3. <u>International (public and private sector)</u>

a. Name
b. Affiliation/funding source(s)
c. Date of establishment
d. Areas of research activity
e. Relevance of research to small and medium farmers in country
f. Nature and extent of in-country activity
g. Linkages and collaboration with national programs (Research, Extension, other)
h. Linkages with agrosupport firms and institutions operating in country
i. Methods of determining research priorities
j. Extent of on-farm research
   i. in country
   ii. under similar ecological and farmer conditions
k. Major research contributions in past decade relevant to country
l. International networking and diffusion mechanisms and programs

B. **National Extension and other technology transfer institutions and programs (public and private sector)**

1. Name
2. Affiliation
3. Location(s) (include map if appropriate)
4. Facilities
5. Organizational structure
6. Staff (names, positions, training and experience)
7. Methodology
   a. Program planning
   b. Information dissemination
      i. planning and use of communication media/channels
   c. Technical backstopping
   d. Feedback and networking
   e. Training

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f. Evaluation

8. Current program content
9. External donor support (nature and extent)
10. Linkages with research institutions/programs
11. Linkages with other technology diffusion institutions/programs
12. Linkages with agrosupport sector

C. **National agricultural technology generation and transfer system**

1. System diagram
   a. Line and staff relationships
   b. Information flow (two-way) relationships
   c. Linkages with regional and international programs
2. Areas of strength and apparent weakness

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Agricultural Technology Identification and Assessment
Africa

V.

AGRICULTURAL TECHNOLOGY ASSESSMENT
By
INDIVIDUAL TECHNOLOGY OR TECHNOLOGY SYSTEM

(Preliminary identification and assessment to be made during pre-survey preparation stage for verification and additions in the field)

Country:

A. Descriptive title

B. Source(s) of information

C. Source of the technology or technology system

D. Description of technology or technology system

E. Existing situation or problem it could alleviate

F. Extent to which problem is recognized by farmers

G. Conditions under which adapted d potentially appropriate (ecological zones and farmer situations)

H. Potential positive consequences from its use

I. Potential negative consequences from its use

J. Relationship to existing practice/system

K. Degree of confidence in local adaptation and how determined

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L. Possibilities for incremental adoption

M. Extent of present usage of technology or technology system by subsistence, subsistence/commercial and commercial farmers

N. Constraints to increased adoption

1. Agricultural
2. Institutional
3. Socioeconomic

O. Observations (including adequacy of technical assistance presently available to farmers locally, and likelihood of need for additional national, local and/or external technical assistance)

P. Factors/issues requiring further study and analysis

Q. Stage of readiness for diffusion to farmers

R. Estimated time likely to be required for achieving widespread adoption

S. Recommendations for improving diffusion

Assessment made by:_____

Date:_____

Agricultural Technology Identification and Assessment
Africa

VI.

SUMMARY OF AGRICULTURAL TECHNOLOGIES IDENTIFIED, BY STAGE OF READINESS CATEGORY*

Country: _____

Technolog,	logy system	Source	Adaptation Zones	Adaptation Farmers	Major con-straints	Complexity of tech.	Poss. incre. adoption	Est. diff. time
A. Ready for d. ion.								
B. Almost ready for diffusion								
C. Promising for the future								

* See following page for explanations and codes

EXPLANATIONS AND CODES FOR SUMMARY TABLE

Col. 1. Technology/technology system

Insert descriptive title from Appendix A, Section V.

Col. 2. Source

Where technology originated and by what institution.

Codes to be developed during pre-survey preparation.

Col. 3. Zones

Ecological zones.

Codes to be developed for each country during pre-survey preparation.

Col. 4. Farmers

Codes:	S	-	subsistence farmers
	S/C	-	subsistence/commercial farmers
	C	-	commercial farmers
	G	-	group farming
	P	-	plantation or estate farmers

Col. 5. Major Constraints

Codes:	A	-	agricultural
	B	-	institutional
	C	-	socioeconomic

Col. 6. Complexity of technology

Code key:

1.1.1

- 1 — Individual vs. community or group action.
- 1 — Incorporability into farmers' current management systems.
- 1 — Level of inputs required.

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Col. 6 Codes:

Input level

1._._	None
2._._	Low
3._._	Medium
4._._	High

Incorporability into farmers' current management systems

_.1._	similar to existing practice; no serious mgmt./skill problems.
_.2._	Moderate practice change; some management/skill problems.
_.3._	Major practice change; serious management/skill problems.

Individual vs. group or community action

_._.1	Can be adopted by farmer as an individual (e.g., a new crop variety).
_._.2	Requires group or community action for adoption (e.g., irrigation system management).

Col. 7. Possibility for incremental adoption

Codes:	1	-	Yes, entirely feasible to adopt in stages.
	2	-	Possible to adopt in stages under some circumstances.
	3	-	No, must be adopted in its entirety.

Col. 8. Estimated diffusion time

Record estimated number of years required to achieve widespread farmer adoption.

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VII.

ILLUSTRATIVE LIST OF AGRICULTURAL, INSTITUTIONAL AND SOCIOECONOMIC FACTORS TO BE CONSIDERED IN ASSESSING TECHNOLOGIES

A. AGRICULTURAL ELEMENTS

1. Weather

   a. Macro- and micro-climatic factors which influence feasibility of the technology in a given region
   b. Range of variability

2. Soil Factors

   a. Nutrient status, acidity
   b. Water holding capacity
   c. Drainage
   d. Erosion, erodability
   e. Slope

3. Agronomic Factors

   a. Yield potential (crop, fuel, forage, stakes, other by-products)
   b. Varieties
   c. Planting material
   d. Establishment system
   e. Planting geometry
   f. Existing cropping systems
   g. Effects on soil and water conservation, and wind and water erosion

4. Livestock

   a. Appropriate species
   b. Breeding stock
   c. Use (draft, slaughter, transportation, etc.)
   d. Nutrition
   e. Crop/livestock interactions

5. Pests (insects, pathogens, nematodes, weeds, animals, animal diseases)

   a. Relative importance and severity of the different pests
   b. Extent and nature of loss from pests

c. Will use of the technology (e.g., alley cropping) increase or decrease the severity of pest problems on the crops and animals in the farming system?
d. Are tree species free of pest problems?

6. Long term ecological effects

a. Potential benefit
b. Potential harm

7. Farming system management

a. Knowledge and skills
b. Resources

8. Uses of new vs. existing crops

a. Increase food production
b. Improve human and animal nutrition
c. Prevent erosion
d. Minimize purchased inputs (e.g., fertilizer)
e. Provide forage for animal production

9. Potential for building on existing systems and technologies

a. Selection of target area
b. Careful evaluation of current situations
c. Crop combinations
d. Cultural practices
e. Incremental introduction (by stages)

10. Short and long term effects

a. Positive
b. Negative

B. INSTITUTIONAL ELEMENTS

1. Adequacy of input delivery systems

a. Fertilizers, insecticides, herbicides
b. Trees/seeds/tubers
c. Machines/tools
d. Credit
e. Private/public sector interface

2. Production objective

a. Subsistence

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b. Subsistence/market economy
   - local food security
   - domestic sale and consumption
   - export
c. Commercial
d. Improved nutrition
   - Vitamin A

3. Land tenure/traditional rights

   a. Property ownership
   b. Potential technology impact on land tenure arrangements
   c. Tree tenure
   d. Animals - migratory

4. Adequacy of Market infrastructure

   a. Market access
   b. Marketing constraints

5. Infrastructure for technology diffusion

   a. Organizations (farmers, other private and public sector)
      - what
      - where
      - purpose
      - how they relate
      - formal/informal
   b. Communication infrastructure (e.g., radio)

6. Organizational interest in technologies

   a. Government
      - institutional incentives
      - rules/regulations
   b. Private
   c. Educational
   d. Traditional (e.g., tribal)

7. Incentives

8. Risk protection

9. Magnitude of impact

   a. Technical capability to generate impact
   b. Size of audience for which technology is suitable
   c. Cost effectiveness of a communication program

10. Hierarchical messages (macro--->micro flow)

   a. Components of the technology with broad application

b. Highly location-specific components
c. National-regional-local media use and applicability
d. Amenability to mass communication approaches

11. Short and long term goals (including educational)

a. Societal goals
b. Individual goals
c. Incremental development

C. SOCIOECONOMIC ELEMENTS

1. Economic factors

a. Prices (input:output ratios)
b. Profit (enterprise analysis)
c. Labor profiles
   - use (time/activity)
   - price (time/activity)
d. Risk (wealth/utility)
   - individual assets
   - stability of production
e. Economic management
f. Resource base identification

2. Non-economic values

a. Cultural
b. Religious
c. Social
d. Political
e. Traditional
f. Quality of life

3. Similarity of new to existing or earlier systems

a. Existing vs. new behaviors
b. Relationship of technology or existing system to household gardens
   - practice/crop analysis
   - institutional support

4. Incentives

5. Societal goals

6. <u>Realistic expectations relative to degree of change resulting from a new technology or system</u>

   a. Short term
   b. Medium term
   c. Long term

7. <u>Consequences of adopting new technology</u>

   a. Cost
   b. Positive consequences
      - immediate
      - intermediate
      - long term
   c. Reinforcers for adoption
      - temporary (artificial)
      - permanent (environmental, habitual)
   d. Negative consequences

8. <u>Vectors of change</u>

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Appendix 2

PLANNING MEETING REPORT

Appendix 2

Communication for Technology Transfer in Agriculture (CTTA)
AID/S&T Project 936-5826

REPORT ON THE PLANNING MEETING FOR AGRICULTURAL TECHNOLOGY SYSTEMS IDENTIFICATION FOR AFRICA

20 August 1986
Washington, D.C.

The Communication for Technology Transfer in Agriculture (CTTA) Project is jointly managed and funded by the Offices of Education, Agriculture, and Rural Development of the Bureau for Science and Technology of the United States Agency for International Development in collaboration with Regional Bureau Technical Staff and the USAID Mission at each collaborating site. Technical services are provided by the Academy for Educational Development under Contract No. DPE-5826-C-00-5054-00.

REPORT ON
PLANNING MEETING FOR
AGRICULTURAL TECHNOLOGY SYSTEMS IDENTIFICATION FOR AFRICA

20 August 1986
Washington, D.C.

EXECUTIVE SUMMARY

A blue ribbon panel of agricultural, communication, development, behavioral science, and social marketing experts from the Agency for International Development, U. S. universities, private sector organizations, and the Academy for Educational Development participated in a one-day meeting to plan for a survey of agricultural research systems to identify available technologies appropriate for Africa.

The objective of the meeting, sponsored by the Communication for Technology Transfer in Agriculture (CTTA) Project and hosted by the Academy for Educational Development (CTTA Prime Contractor) was:

> To identify critical institutional, agricultural, and socioeconomic elements that should be included in an analytical framework for identifying and assessing the stage of readiness for diffusion to farmers of appropriate agricultural technologies.

The CTTA Project is developing strategies and methods to provide effective communication support to technology transfer. A basic assumption of the Project is that there are appropriate technologies ready to extend, as technology generation is outside the CTTA scope of work. Particularly in Africa, however, a preliminary review of agricultural technologies and technology systems has confirmed their great diversity, leading to problems in determining those most appropriate to include in a communication program. Some technologies appear to fit into an "almost ready" rather than a "ready" category, and others which appear promising for the future still require significantly more research or institutional adjustments. In neither case are such technologies ready for diffusion in the short term.

With funding assistance from the AID Bureau for Science and Technology Small Activities Project, the CTTA Project will survey available agricultural technologies and technology systems -- indigenous or imported -- in up to four selected African countries. National programs, international agricultural research centers (IARCs), and other collaborative research programs involved with technology generation and diffusion applicable to each country will be surveyed to identify and assess the stage of readiness for diffusion of technologies potentially appropriate for farmers

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in the country. For technologies considered to be proven (almost ready) and ready for diffusion, the study also will identify issues that must be analyzed and how, and include recommendations to improve the diffusion process.

In addition to identifying technologies ready for diffusion to farmers in the selected countries, which will also help to determine countries which meet the "available technology" criterion for selection of CTTA collaborating countries, the study should provide information of value to national programs and donor agencies concerning institutional and related issues that must be addressed to move promising technologies to the ready stage.

Agricultural, institutional and socioeconomic elements critical to the identification and stage of readiness of appropriate technologies were discussed during the meeting in the context of three potentially viable low resource technologies -- drought resistant crops, response farming (water production function package), and alley cropping. The format consisted of a presentation of the technology, followed by brief statements of agricultural, institutional and socioeconomic issues relevant to the technology by a specialist in each of these areas, and by open discussion characterized by highly productive interdisciplinary interaction.

About 20, 45, and 35 critical issues related to agricultural, institutional, and socioeconomic considerations, were identified during the meeting in addition to those suggested by the technology presenters. Although offered in relation to a specific technology, they provided a solid basis for development of an analytical framework applicable to the range of technologies likely to be encountered during the survey. (A smaller panel later synthesized these issues and other insights gained from the meeting into a draft analytical framework to be used by the survey team.)

During the concluding session, attention was again called to the necessity for CTTA to have good agricultural technologies. The importance of local research capability was stressed, and the comment was offered that national agricultural research staffs have been generally frustrated by the apparent inability of extension services to communicate technologies to the farmer. The need for the survey framework to consider questions from the perspective of the USAID Missions was also emphasized.

REPORT ON
THE PLANNING MEETING FOR
AGRICULTURAL TECHNOLOGY SYSTEMS IDENTIFICATION FOR AFRICA

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REPORT ON
THE PLANNING MEETING FOR
AGRICULTURAL TECHNOLOGY SYSTEMS IDENTIFICATION FOR AFRICA

20 August 1986
Washington, D.C.

PURPOSE AND GOALS

Purpose

The Communication for Technology Transfer in Agriculture (CTTA) communication program can have impact only where appropriate, adapted, and otherwise viable technologies are available that can be beneficially adopted by farmers, taking into consideration their own constraints and within the existing institutional framework. It will not create new or improved technologies. Therefore, CTTA places strong emphasis on the identification and assessment of technologies that will be disseminated to its target farmers.

The purpose of the Agricultural Technology Identification and Utilization activity, funded by Dr. Nyle Brady's Small Activities Fund, of which the Planning Meeting for Technology Systems Identification in Africa is part, is to survey technologies appropriate for Africa -- indigenous or otherwise -- available from agricultural research systems in the region to identify and categorize those which are:

> Ready for diffusion: those which can be beneficially adopted by farmers within the present institutional framework and within the farmers' own constraints.
>
> Proven technologically: those which can be adopted by farmers with only moderate institutional modification and support.
>
> Promising for the future: those which will require substantive institutional modification before they can be adopted and used beneficially by farmers.

Recommendations to improve the diffusion process for ready and proven technologies also will be developed.

Scope

Major institutions involved with technology generation and diffusion in up to four selected African countries will be surveyed. For technologies considered to be ready and proven, the survey also will identify issues that must be analyzed and how information can be obtained with respect to each.

Sequence of activities

1. Planning meeting on 20 August 1986 to:

   - review analytical approaches currently used in technology and technology systems research and development relevant to Africa, and

   - identify critical institutional, agricultural, and socio-economic elements that should be included in the analytical framework for surveying available agricultural technologies appropriate to the African countries selected for the study.

2. Synthesis Panel meeting on 3 September 1986 to:

   - develop an analytical framework for the Africa survey, using as a major resource insights and conclusions from the 20 August meeting;

   - suggest African countries to be surveyed; and

   - identify critical disciplines to be represented on the survey team.

   (The Synthesis Panel subsequently met as scheduled and the analytical framework now is in draft form.)

3. Survey the selected African countries, in cooperation with the Office of Agriculture and Rural Development of AID's Africa Bureau.

4. Prepare a report for each country surveyed that contains a discussion of available technologies and recommendations for their diffusion, and an additional overview report which integrates those findings.

Anticipated outcomes

1. Identification of ready technologies available for diffusion in the countries surveyed. This also will help determine countries which meet the available technology criterion for selection of CTTA collaborating countries.

2. Determination of issues to be addressed to move proven technologies to the ready stage.

3. Although not a specific CTTA objective, the study should also provide information of high value to national programs and donor agencies concerning institutional and related issues that must be addressed to move promising technologies to the proven and ready stages.

OPENING REMARKS

Dr. Howard Ray
CTTA Project Director

The CTTA communication process

The impact of a communication program in support of agricultural technology transfer can be no greater than the relevance, importance, and appropriateness of information being disseminated to farmers. Therefore, the CTTA Project places strong emphasis on the identification and assessment of the technologies that will constitute its messages to those farmers.

CTTA will not create technology, but the project must be fully involved in selecting technologies that it will communicate to farmers. Therefore, the identification and assessment of appropriate technologies for a given situation is a high priority activity.

Particularly in Africa, a preliminary review of agricultural technologies and technology systems has confirmed their great diversity, leading to problems in determining those most appropriate to include in a communication program.

We have been fortunate, and are most appreciative of receiving support from Dr. Brady's Small Activities Fund to make a survey of available agricultural technologies and technology systems--from international agricultural research centers (IARC), other collaborative research programs, and national programs. The objective of this study will be to identify technologies --indigenous or otherwise -- in up to four selected African countries, that are:

> Ready for diffusion.
>
> Proven technologically, but which require modest institutional modification and/or support to enable farmers to adopt them.
>
> Promising for the future, but which will require substantive institutional modification before they can be adopted and used beneficially by farmers.

The first step in preparing for this study is to develop an analytical framework for technology identification and assessment that includes the critical institutional, agricultural, and socioeconomic elements to be addressed. This meeting will begin this process, taking advantage of the insights and experience gained through several currently used approaches.

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Following today's discussions, a smaller group comprised of

Ans Burgett	-	AID/AFR/TR/ARD
Kenneth Swanberg	-	AID/S&T/RD
Raymond Meyer	-	AID/S&T/AG
David Thurston	-	Cornell University
Howard Ray	-	CTTA Project Director, AED
Anthony Meyer	-	AID/S&T/ED

will synthesize the insights and conclusions from today's meeting into an analytical framework to be used for the study.

We expect the survey to provide not only information needed by CTTA, but also information that will be valuable in designing and implementing programs to alleviate present non-communication constraints to the use of technologies in the second and third categories.

We also plan to incorporate this framework into the CTTA process for determining technical message content in all countries in which we operate -- in Latin America, Asia and Africa.

Thus, we place high importance on today's deliberations, and are looking forward to animated and frank discussion which will lead to synthesis of a serviceable and valid analytical framework for identifying and assessing technologies.

Meeting format

The remainder of today will be directed toward achieving the meeting's specific objective:

> To identify critical institutional, agricultural, and socioeconomic elements that should be included in the analytical framework for identifying and assessing the stage of readiness for diffusion to farmers of appropriate agricultural technologies.

To facilitate our task, we would like to begin discussing the critical elements in the context of three potentially viable technologies for Africa. Then, we would like to broaden the framework to make it more generally applicable to identifying and assessing a wide range of technologies appropriate for use in any country.

As indicated in the agenda, we will separately address each of the three technologies. To provide a common basis of understanding, each technology will be briefly described. Then, to open the discussion and focus sharply on the socioeconomic, institutional, and agricultural issues relevant to that technology, we have asked three persons to highlight some of the issues relevant to each as related to the technology or technology set. From that point, we hope everyone will contribute freely to the discussion.

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I would request the moderators of each session to keep us on track -- to use the technology as a basis for identifying critical elements in the three types of analysis, rather than concentrating on trying to make an assessment of the technology.

Dr. Ruth Zagorin
Director, Office of Human Resources
AID/S&T/HR

Good morning. On behalf of the Bureau for Science and Technology, Dr. Peter McPherson, and Dr. Nyle Brady, who could not be here today, I welcome you all to this exciting exercise.

A hallmark of the CTTA Project is its interdisciplinary nature. It is heartening to see that many perspectives are represented here, especially as Dr. Brady, through whose Small Activities Fund is making this activity possible, and I share a special interest in the coming together of agricultural and social sciences to address problems of the nature being discussed here today.

The CTTA Project is developing a methodology to provide communication support for technology transfer. Ideally, the Project supposes there are ready technologies available to extend. This has been more the case in Latin America and Asia than in Africa. Often technologies are more "almost ready" than ready, and the CTTA Project can be a catalyst for the decisions and activities required to make them ready. Some technologies require significantly more research or institutional adjustments and are not ready for diffusion in the short term. Because there may be few technologies that are absolutely ready for broad transfer to farmers, I would urge that you not be too conservative in your identification and classification of ready technologies.

This meeting will develop an analytical framework for determining the degree of readiness of technologies for diffusion, with Africa as the primary focus. The examples of drought resistant crops, response farming, and alley cropping are well chosen and discussing them should provide valuable insights for developing the analytical framework desired from today's meeting.

Africa has great need to increase food production. I genuinely hope this exercise and the communication methods of the CTTA Project will have an impact there.

Dr. Anthony Meyer
CTTA Cognizant Technical Officer
AID/S&T/ED

CTTA's objective is to develop a methodology to provide optimal communication support for technology transfer in agriculture.

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The Project is attempting to go beyond the common ad hoc use of audio visual aids in extension to more comprehensive multiple channel systems that apply the best of what we know from the behavioral sciences, instructional design, and social marketing. Farmer feedback and local institutional capacities have a primary definitional role in the methodology.

Well, all this is well and good if there are technologies to transfer.

In this regard, Africa is an exciting challenge. As our colleagues in the Office of Technical Assessment and many of you in the room have pointed out, Africa is rich with appropriate, low-resource technology. How to integrate these technologies with the necessity to increase food production and income is not completely understood. In fact, as a project like CTTA learns of these low resource technologies, or of technologies to improve their impact, it is not always clear which are ready for broad diffusion and adoption and which require further testing and adjustment.

As the CTTA Project began to work with a variety of other projects and activities in Africa, this common problem appeared to need addressing. It is for this reason that we are meeting today to develop an analytical framework, using a few example technologies, for addressing the readiness of various technologies in Africa.

I want to thank Dr. Howard Ray and the Academy for Educational Development for organizing this meeting, along with CTTA subcontractors Cornell University and Applied Communication Technology, and collaborating institutions.

DROUGHT RESISTANT CROPS

Moderator:	Dr. D. Thurston
Technology Presenter:	Dr. R. Meyer
Discussants:	Dr. H. Ray
	Dr. G. Honadle
	Dr. J. Axtell

Drought Resistant Crops: The Technology

Dr. R. Meyer

Drought resistance in crops is a complex of various morphological and physiological plant factors that interact with climate and soil characteristics. The primary site of drought stress on plants has not been carefully defined; there is no one factor that is dominantly important in all crops, in all soils, or all climates.

The variety component

It is important to put the variety component (in the broadest sense) in perspective with regard to improved production. Analyses of production increases in crops such as barley, maize, wheat, and rice show that the variety component contributes less than half to production increases -- the major influence coming from higher fertilizer rates and better agronomic management.

Information for sorghum indicates that about one-third of the crop production increase in the U.S. is due to genetic change. The concept that breakthroughs in production in developing countries depend on new high yield varieties is restricting and not true in stressful environments. In stressful environments, yield stability is highly important, and the first limiting component is often not the variety but agronomic factors such as soil moisture management, nutrients, timely planting, and weed control. Traditional varieties frequently are very responsive to improved management, indicating that the variety yield potential does not restrict production. Improved agronomic practices can have immediate effects while plant breeding results have a longer time horizon.

Assured moisture supply and reducing risk to make investments in inputs feasible provided the interaction with high yielding variety potential necessary for large payoffs in the classic green revolution wheats and rices. Those basic factors do not apply to sorghum, millet, or other dryland crops. For these, potential production must be measured against other factors.

In most dryland countries, improving varieties rather than producing hybrids may be a good strategy, and one which does not divert limited resources to building the infrastructure necessary for hybrid seed production. It has been shown that large increases in production can be obtained by small-scale farmers in dryland conditions by integrating improved varieties with improved agronomic practices that do not need tractors or heavy chemical fertilizer applications.

It must also be remembered that plant breeders have not made significant strides in increasing biomass production potentials. Grain production potentials have increased because of changes in harvest index. It is questionable whether this is the best strategy for livestock-based agricultural systems.

Crop improvement and drought resistance

One approach for developing material capable of performing under soil water deficit conditions is based on the premise that the relative ranking of genotypes for yield ability is similar across environments. Selection programs based on this concept are usually conducted under optimal conditions because heritability of

yield and yield components is relatively high and selection is more efficient.

A second approach contends that potential yield is irrelevant. Superior cultivars must be developed and selected in the environment in which they are expected to perform. Cultivars developed in such manner show a very narrow environmental adaptability and exhibit extremely large genotype x environmental interactions.

A third, evolving, approach depends on strong interaction among breeders, geneticists, physiologists, and soil scientists. Large differences exist in available germplasm for almost any characteristic desired. By defining the relationships between developmental, morphological, and physiological characteristics and drought avoidance and tolerance, vast improvement in total drought resistance can probably be achieved.

Other crops

Indigenous crops such as amaranth, quinua, winged bean, and tarwi frequently are recommended as drought resistant crops but the information base for them is limited and it is frequently difficult to make viable recommendations for specific environments.

It is important to note that while some of these crops may be drought resistant under subsistence management, at higher management and yield levels they may be greatly affected by drought. The bases for making decisions concerning investments in developing new or indigenous crops rather than better known commercial crops are not really available at this time.

Conclusions

The need to improve drought resistance and thus productivity of crops grown in drought-prone environments is obvious, but the approach to the task is less so. No single mechanism will convey drought resistance to green plants under all drought conditions. The type of drought which is most likely to exist at a particular site must be carefully defined. The type or types of mechanisms most likely to allow the plant to remain productive must then be incorporated into germplasm destined for that environment. Until one can adequately define the most probable type of drought, little success will be made in increasing drought resistance in a measurable quantity.

The hope is that almost any mechanism that is desired currently exists and can be exploited for use in crop improvement. A high degree of genetic variability exists in the limited germplasm evaluated at this time. There is real promise for improvements to be rapid. If we can incorporate water conservation mechanisms such as increased photosynthesis per unit conductance with tolerance mechanisms such as more effective roots and osmotic adjust-

ment, we can make great varietal improvements in a crop's use of its water resource.

Progress will be made. The rate of improvement will depend upon the degree and extent of cooperation between several disciplines.

Drought Resistant Crops: The Socioeconomic Perspective

Dr. Howard Ray

Three elements -- economics, behavior, and social marketing -- will be reviewed briefly as background for suggesting the following illustrative list of questions regarding drought resistant crops from the socioeconomic perspective. All assume the new technology -- crop or crops selected -- is adapted to the region under consideration and is biologically superior to the farmer's present practice.

1. Is there enough unsatisfied demand for the produce -- commercially or for home consumption -- to justify a program to significantly increase production of the crop?

2. Is the product price stable and sufficient to permit the farmer to realize a reasonable profit from its sale, taking into consideration all production costs?

3. Will production of the crop decrease the risk of crop failure or economic loss in comparison to crops presently being produced? No change? Increased risk?

4. Can adequate seed supplies and other needed inputs be made available to farmers at the time needed and at prices consistent with question 2?

5. How complex is the production technology for the new crop? Are production practices for the new crop sufficiently similar to those presently used to enable farmers to produce the new crop successfully without learning new management skills?

6. Do the farmers have the necessary labor, materials, implements, etc., needed to produce the new crop?

7. What benefits will the farmers derive from planting the new crop in comparison to crops they are presently growing -- greater monetary return, less labor, lower risk, higher community status?

8. Are there potential negative consequences to the farmers who plant the new crop? If so, what are they?

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9. Is the new crop acceptable to farmers in the area? Are there cultural or other hidden constraints to adoption from the farmer's viewpoint?

10. Among the various drought resistant crops that may be biologically appropriate, which one or ones are most viable, taking into consideration issues suggested by the questions posed above?

Many other issues and questions are equally relevant, and must be considered. Some will be raised by those looking at drought resistant crops from the institutional and agricultural perspectives -- and some of these suggested here will undoubtedly be repeated. The objective is to stimulate discussion and sharpen the meeting's focus on elements to be included in an analytical framework for identification and assessment of the stage of readiness for diffusion of appropriate agricultural technologies, with initial emphasis on selected African countries.

Drought Resistant Crops: The Institutional Perspective

Dr. George Honadle

Institutional analysis of the potential of a new agricultural technology for widespread adoption requires a high level of two-way, interactive, communication. From an institutional perspective, the potential for adoption of a new technology, such as drought resistant crops, depends on answers to questions from four different viewpoints: 1) development and selection, 2) technology production, 3) delivery methods, and 4) absorption.

Development and selection

1. Can the technology be privately owned and managed?

2. What resources -- capital, education, management -- are required for developing and testing the technology?

3. Who within the institutional system for which the technology is designed will set the decision-making priorities for technology development, testing, and introduction?

4. Are there appropriate sites within a locality for technology development and selection to take place -- laboratories, research farms, test plots?

Technology production

1. Are there capital and labor resources available for producing the new technology -- for instance seed multiplication facilities for new varieties?

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2. Are production units of appropriate scale for producing enough materials for the technology to be introduced?

3. Are governmental and private institutional policies favorable for technology production?

4. Does the legal system and do legal requirements favor or allow production of the desired technology?

Technology delivery

1. Is the new technology deliverable through public or private contracts or both?

2. Must users of the new technology participate interactively with the technology delivery system or is it one-way delivery?

3. Does delivery of the new technology require concentrated or dispersed resources?

4. Can the current transportation and communication infrastructure meet the demands for delivering the new technology?

5. Will existing institutions be capable of delivering the new technology, or must new institutions be created?

Absorption

1. What are the boundaries of the areas within which a new technology may be absorbed?

2. How will traditional values (prices) affect the introduction of a new technology?

3. Will widespread adoption of a new technology change local cultural and social balance? What groups have an incentive to stop the introduction of a new technology?

4. Are incentives for adoption of a new technology for groups or individuals?

5. What will be the physical impact of the adoption of a new technology on the farmers who use it?

6. What behavior change will be necessary for a technology to be absorbed by the target audience? Is there a large gap between current behavior and that required by the new technology? Is a new behavior required?

Drought Resistant Crops: The Agricultural Perspective

Dr. John Axtell

In addition to those questions raised regarding the agricultural suitability of technologies during Dr. Meyer's description of drought resistant crops, I would emphasize the following considerations in judging their appropriateness for widespread adoption in Africa.

1. What are the soil requirements and related water regime requirements of the new technology? And, how will the new-crop(s) affect current soil status?

2. What level of agronomic management is required by the new technology? New crop varieties often need management different from that needed by traditional varieties. Case studies can help answer these questions.

3. How stable are the yields of the new crops? This is particularly important because subsistence farmers are highly risk aversive.

4. Introducers of drought resistant/tolerant crops should beware that this aspect of plant breeding is relatively new and limited to only a few crops and regions.

5. The utility of a new crop and its food value should be considered. For example, in one study African villagers preferred sorghum to maize because they were familiar with sorghum milling and cooking practices. An urban population in the same country preferred maize for the same reason. There is a substantial lack of research to identify local crop/food utilization practices.

Drought Resistant Crops: Open Discussion

During open discussion of drought resistant crops, the following questions were identified as important in determining the suitability of the technology for transfer to farmers. The questions are grouped by perspective -- agricultural, institutional, socio-economic.

Agricultural perspective

1. Where does the seed come from? Will enough be available at planting time? How is seed produced and who produces it? How is seed stored, treated, and distributed? What does seed cost farmers and who sets the prices? What is government seed policy?

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2. Is there, and what public and private agencies are conducting, multidisciplinary testing of requirements and consequences of new varieties and crops; for example, soil testing, insect pest monitoring, disease monitoring.

3. What are the sources of new and improved agricultural technologies? Are they the international agricultural research centers? public institutions? private organizations? external aid agencies?

Institutional perspective

1. What incentives are there for farmers to adopt a new variety or crop?

2. What are the policy maker motivations for desiring adoption of a new technology, and what are the motivations of farmers to adopt the technology?

3. To encourage creation and adoption of new and appropriate agricultural technologies, where are the most important areas for institutional investment -- research and development? transfer? definition of existing technologies? improvement of management of existing technologies?

4. How can the presently available vectors of change within a culture be harnessed to speed introduction and adoption of new technologies? Is the decision-making frame of the society in which a new technology is to be introduced traditional or changing?

5. What are the input requirements of the new technology and what impact will they have on delivery systems and the environment?

Socioeconomic perspective

1. What are the cultural expectations of the technology? Is the new technology readily usable by a broad range of farmers?

2. What is the cultural class of the variety or crop to be introduced? Some cultures rate cereals higher than tuber crops, and vice versa.

3. Are farmers dissatisfied with the current agricultural situation, and thus more willing than might be normal to experiment with a new technology?

4. What are the risks of adopting versus not adopting a new technology? In a risk aversive society, the lack of negative consequences to the adoption of a new technology may be more important than the presence of positive consequences.

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5. How long is the payoff period of adopting a new technology?

6. What are the labor constraints of a new technology? Labor should be viewed in the following contexts: family, hired, family + hired, sex, culture, the larger economic situation, and within subsistence and commercial farming contexts.

7. What are the target audiences of the change in technology - public, private, group, individual, etc.?

RESPONSE FARMING

Moderator:	Dr. K. Prussner
Technology Presenter:	Dr. I. Stewart
Discussants:	Dr. J. Woods
	Dr. D. Porter
	Dr. A. Burgett

Response Farming: The Technology

Dr. I. Stewart

Response farming means farmers receive better information than they now have as to the expectation for rainfall in their specific locality during the approaching cropping season, and that their decisions are influenced by the improved knowledge. A complete response farming system will additionally provide farmers better information as to how best to respond to any rainfall forecast.

Response farming uses the research activities and findings of others rather than replacing them. However, it is also true that I and colleagues at the University of California, Davis, Western U.S. Universities, and in Kenya have, during 20 years, elaborated a specific package of research methodologies termed water production function research, designed to generate a maximum of response information in the shortest time possible with the least input of effort, research resources, and money.

Therefore, the response research and teaching program is appropriate wherever agricultural research in general is appropriate. The appropriateness of the rainfall forecasting portion depends on the degree of improvement in forecasting that can be achieved in the given locale, using the crop specific rainfall analyses developed for this purpose. In Kenya, where response farming was developed, the level of rainfall predictability is only moderate, but nevertheless sufficient to provide a wealth of useful information for better matching of practices with actual rainfall. On-farm validation trials over four growing seasons were totally successful.

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Equal predictability to that in Kenya has been demonstrated in a transect across the Mediterranean including Morocco, Cyprus, and Jordan. Still better predictability has been found in the Lower Terai of Nepal, on the border of northern India. I now believe the approach to be sound virtually everywhere, but there is no doubt that both the degree and nature of usefulness will vary from place to place.

Key points for preliminary analyses are:

- Availability of long term (15 years) daily rainfall records. A cluster of analyses reveals more information than a single analysis and establishes a basis for interpolating into areas where meteorological data are not available. Note that in tropical Africa few additional meteorological data are required.

- Where programs to improve agricultural production are seriously considered, a survey is required of present farming systems, key soil characteristics, and important socioeconomic and institutional factors.

Salient characteristics of response farming

Response farming employs newly developed rainfall analyses oriented to producing specific crops in designated localities to quantify criteria for predicting a narrowed range of possible rainfall amounts, and of possible rainy period durations, in the approaching or just beginning rainfall season.

Simple analyses suffice to assess rainfall predictability. More sophisticated analyses employ transferable equations from water production function research to go back through the record and assess for each past season how much rainfall should have been utilized by the study crop in the study locality (considering other meteorological parameters, soil characteristics, and accepted management practices), and how much yield should have resulted. This process may be done for any number of different crops whether actually grown or simply proposed.

Most important farm management decisions/practices affect both crop water use and yield. The response farming system in its completed form includes a <u>water production function research package</u> to be conducted in the developing country, to quickly ascertain optimal management responses to different rainfall forecasts.

Potential benefits

One of the greatest potential benefits is maximum food security at least cost in low rainfall seasons. Stewart and Faught (1984) found that in Eastern Province, Kenya, total crop failures with maize can be reduced from the conventional one season in two to

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one season in seven with medium level management guidance (response farming guidance without the use of commercial fertilizers or other costly inputs), and to one failed season in nine with high level management (inputs included).

Another benefit is excess production to market, thus breaking the poverty syndrome, in high rainfall seasons. Better forecasting of the rains accompanied by more fitting fertilizer, etc., recommendations, will reduce risks to normal farming levels, thus making farmers willing to invest, and lenders willing to back them.

Potential constraints

Potential constraints include unavailability of rainfall data, which may be overcome by regional correlation studies and interpolation and research. Inadequate infrastructure or supply systems to handle inputs with demand possibly changing radically in short time periods.

Response Farming: The Institutional Perspective

Dr. John Woods

When analyzing a technology such as response farming from an institutional perspective it is essential to identify and keep in mind the institutional goals for introducing the technology, the technology receivers, and the strategies for technology introduction. Following are some questions and considerations that have impact upon institutional appropriateness of a new technology.

1. What organizations are involved in introducing the technology and what are their roles in the introductory process--research, regulatory policy, credit generation, feedback? How do they decide to introduce a new technology? What are the incentives for the organizations to successfully introduce the technology?

2. What are the policies and procedures that influence the introduction of a new technology?

3. What problems are being encountered in introducing the technology, and what strategy, if any, is being used to introduce it? Are there markets for the new technology or its product?

4. Are there gaps in the agricultural research-extension-farmer continuum, and where in the continuum is the source of the technology? Is the technology globally based, scientifically based, or technologically based?

5. Is there a diagnostic framework in place for evaluating new technologies or must such a framework be developed?

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6. For successful transfer of new technologies, there must be an unbroken chain of activity between the developing agents and the farmer. Links in this chain likely will include technology generation, progressive research, planning and management, production and distribution inputs, communication support, and human resources.

7. Developmental projects must be treated as a social system with interaction at national, regional, and local levels. Developing a conceptual view or organizational inventory of the developmental infrastructure may help trace linkages between institutions that are part of the system and identify those linkages which are not functioning interactively.

8. It is essential to remember that organizations are administered by people for people and that they depend upon the four Cs -- capability, coordination, communication, and commitment.

Response Farming: The Behavioral Perspective

Dr. Douglas Porter

We know there are certain factors, such as positive or negative reinforcement, that control human behavior. Behavior is shaped, maintained, and altered based on consequences. Therefore, when a new technology is introduced, a range of behavior factors must be considered.

1. If there are possible negative consequences to a new technology, how can they be avoided or removed?

2. Are benefits (reinforcement) of adopting the new technology immediate or delayed, and if delayed, for how long?

3. Positive consequences reinforce adoption of a technology. However, if benefits are medium-term or long-term, other, scheduled methods of reinforcement may be needed to maintain interest in a new technology.

4. Behavior is shaped by experience, which is equivalent to intermediate positive or negative reinforcement over time.

5. Current behavior can contribute to farmer attitudes and-change. For example, farmers may place high value on leisure time. If a new technology, although it may produce greater crop yields, requires more labor, farmers will not adopt it if they value their leisure above the added product.

6. Before a technology is introduced, a behaviorist would record what farmers normally do -- on both seasonal and annual

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bases, and on and off the farm. What are habits, consumption patterns, consumption preferences?

7. With this information, a behaviorist could begin to decide what technology characteristics, taken from an individual, family, and community viewpoint, might encourage the maintenance of behavior.

Response Farming: The Agricultural Perspective

Dr. Ans Burgett

In addition to those agricultural requirements identified by Dr. Stewart as necessary for the adoption of response farming, I would like to emphasize the importance of the farmer. The focus of all new agricultural technologies must be the farmer. And in Africa, the focus should include women farmers and consider household as well as individual income.

Additionally, again in the Africa context, response farming must be evaluated in terms of soil types and soil depth and in a wide variety of environments.

Response Farming: Open Discussion

Agricultural perspective

1. Existing agricultural technologies that may be similar and/or complementary to those being introduced should not be ignored.

2. Are enough years of rainfall data readily available for successful use of the technology?

Institutional perspective

1. The mid-level operational dynamics of a technology such as response farming should be considered. An organizational agenda should be identified and an institutional interaction matrix prepared that identifies direct exchanges between institutions, resources required from other suppliers, clients, markets, and shared targets of messages and technologies.

2. How do the results of research reach the farmers?

3. Where in the decision-making hierarchy do the farmers fit? Is there a centralized or decentralized approval process for technologies, and what do the institutions that approve technologies consider in their approval process?

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Socioeconomic perspective

1. Response farming requires the substitution of one crop for another, depending upon rainfall status. What implications do such massive crop changes have on local, regional, and national markets and marketing infrastructure? What are the implications for seed and other input suppliers and distributors?

2. Is the level of education, experience, and management ability sufficient for introducing response farming?

3. Is the technology too behaviorally complex for successful introduction and maintenance? What are the positive and negative aspects of the technology?

ALLEY CROPPING

Moderator:	Dr. K. Swanberg
Technology Presenter:	Dr. C. Martin
Discussants:	Dr. R. Porter
	Dr. J. Thompson
	Dr. D. Osburn

Alley Cropping: The Technology

Dr. Charles Martin

Agroforestry cropping systems (alley cropping) is a system where foodcrops are grown in alleys formed by hedgerows of fast-growing trees or shrubs. Alley cropping is a modification of the bush fallow farming systems practiced by many farmers in the humid and sub-humid tropics.

Woody species in alley cropping systems provide:

- prunings for green manure or mulch for companion food crop(s), or for livestock fodder;
- favorable climatic conditions for soil macroorganisms and microorganisms;
- soil erosion barriers on sloping land;
- firewood and wooden stakes; and
- biologically-fixed nitrogen for companion crops.

Agroforestry systems are generally developed by using fast-growing suitable leguminous woody species such as Leucaena and Flemingia congesta. Although a few woody species have been tested at the farm level, more research work at the station and farm levels is needed. Alley widths currently being tested in Africa range from 2-4 meters. Pruning of woody species is necessary to avoid shading companion crops.

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Potential benefits and constraints

Trees and shrubs facilitate weed control by providing mulching material and by shading soil during the off-growing season. Leucaena, for example, grown at 4-meter spacing, has produced 15-20 tons of fresh prunings (5.0--6.5 tons dry matter) per hectare with 5 prunings per year. Enhancement of soil properties resulting from prunings increases soil organic material and soil nutrient content, but does not increase soil acidity. Additionally, mulching increases soil moisture holding capacity.

Nitrogen-fixing leguminous trees eventually release nitrogen to companion crops through decomposition of prunings, especially when the leaves are incorporated in soil. Experiments have shown that after six years of continuous cropping using Leucaena prunings, maize yields remained at 2 tons per hectare.

Prunings, which can be used fresh or dried for later use, also provide high protein fodder for small ruminants.

Labor constraints to operate an agroforestry system have not been thoroughly investigated, nor is there research on the extra level of management needed to implement an intensive alley cropping system.

Little research on agroforestry systems in arid and semiarid regions exists, although it is being initiated. Also, farm level analysis needs to be conducted to determine the economic benefits of alley cropping to farmers, if any.

Conditions most appropriate for alley cropping technology adaptation by small farmers in Africa

Based on current technology in the humid and sub-humid regions, farmers in these regions may find alley cropping most appropriate. Farmers practicing mixed crop/livestock systems may stand to gain more from agroforestry systems than those practicing monocropping. Alley widths can be arranged to fit farmer commodity interests -- for example, maize, maize + cowpea, and roots and tubers.

Alley Cropping: The Social Marketing Perspective

Dr. Robert Porter

Social marketing is the application of marketing thinking and tools to programs in social change. It is based upon consumer oriented analysis and responds to the wants and needs of target groups. Through social marketing, products (technologies) can be designed to appeal to and satisfy the wants and needs of the target population. To be successful, social marketing must rely upon

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adaptation and coordination of product, pricing, distribution, and communication.

If I were to develop a marketing plan for alley cropping, I would consider the following strategic issues.

1. The target market must be studied and defined. Small farmers are not all alike. Which characteristics are most important in defining the target audience?

2. What marketing tools are available? How should they be deployed? Consider product, price, distribution, and communication.

3. What are the resources for distributing the technology? Can intermediaries and farmers' organizations and associations be utilized as distribution resources?

3. Alley cropping seems most appropriate for subsistence farmers. What effect do the following have on market decisions: access to land, sex-specific duties, home and market consumption, short-term and long-term benefits of the technology, etc.?

4. How will the land tenure system affect technology adoption?

5. What is the division of labor and how will alley cropping affect labor use patterns?

6. Is there market segmentation?

7. How difficult will it be to help farmers develop an accurate perception of costs (direct and indirect) and benefits of adapting the new technology?

It seems that the key feature of the alley cropping technology, at least for farmers practicing shifting cultivation, is that it involves major changes in the time-space organization of agricultural activities.

A study of small farmers in southeastern Ghana indicates that they can spend three or four hours each day walking from their villages to dispersed work sites. Time and labor spent headloading harvested crops from scattered farms to villages is considerable. Moreover, shifting cultivation often makes it impractical to build roads between farms and villages. As long as footpaths are the only links between households and farms, improvements in transportation (and associated time and labor efficiencies) are simply not possible.

Alley cropping, however, could help farmers to farm more continuously on holdings closer to home, thus reducing time spent travelling to work and increasing time available for farming. Reducing

energy expenditures associated with commuting could significantly increase the productivity of farm labor. The impact of alley cropping on the time-space organization of farming might thus involve key consumer benefits.

The related recommendation vis a vis market segmentation is to look for farmers who are cultivating widely scattered plots and who consequently spend substantial time walking to work; these farmers might be especially open to any new technology which would allow them to farm closer to home.

Alley Cropping: The Institutional Perspective

Dr. James Thompson

Following are some key institutional considerations that relate in general to the introduction of any new agricultural technology in Africa.

The institutional constituency for agricultural technologies in semiarid Africa includes:

- land tenure party rights
- tree tenure
- rule making, rule changing, and rule enforcing authority and costs
- markets and prices for products and by-products of a technology
- market and finance institutions
- general institutional infrastructure
- risk aversion structures.

The land tenure situation in Africa is particularly complex in that it can be individual, common, or change depending upon the season of the year. Land tenure has crop and livestock aspects, and perhaps is one of the most important considerations in identifying the appropriateness of a technology such as alley cropping.

Alley Cropping: The Agricultural Perspective

Dr. Donald Osburn

In addition to those points emphasized by Dr. Martin in his description of alley cropping, I would stress the value of knowledge in the following areas.

1. Know the resource base available for adoption of the technology.
   - Who has access to and control of land? Can an individual or a group have title to land? What are the rights of squatters?

- How much labor is available? What are the important cultural aspects of labor use and availability? What are the seasonal aspects of labor availability?

- What capital considerations are important? Is there external capital rationing. What is the external or market availability of capital?

2. Know the performance of the system.

   - What are the products of the system? Are they commercial, for home consumption, or a combination thereof?

   - What are the production and market risks of the system?

   - What is the sustainability of the system?

3. Know the enterprise mix in the interrelationships within it.

Alley Cropping: Open Discussion

With a complex system such as alley cropping, it is extremely important to fully understand the new system and its interaction with existing systems and practices. The following considerations were identified as some of the most important questions regarding the suitability of introducing alley cropping technology to subsistence farmers.

1. Study and clearly identify the requirements of the crop mix within the alley cropping system, including existing off-season land use.

2. Is the new technology environmentally, economically, and socially sustainable? Understand and communicate the limits and constraints, as well as the benefits, of the technology.

3. What are farmer priorities? Are they interested in the technology because it can reduce erosion? Provide animal feed? Produce a cash crop?

4. Study the farmers. How do they respond to risk? Is the area undergoing change that might be harnessed to assist in the introduction of a new technology? What is the level of local agricultural knowledge? Do women participate actively in agricultural activities? What activities? What is their role?

5. How will national policy influence the adoption and sustainability of the technology? Is the legal-political-institutional system flexible to change? Can institutions or individuals change national policy?

6. What is the capacity of the system to promote learning and entrepreneurship? Must farmers receive education to help them make better decisions?

7. Is there a research system -- national or international-- that will continue to support the new technology through ongoing research in areas such as entomology, pathology, soil science, etc?

As a conclusion to the discussion, Swanberg asked the four discussants each to identify their four priority considerations in terms of the suitability for transferring alley cropping technology to farmers.

C. Martin, agriculture, identified:

- identification of labor constraints and local division of labor
- evaluation of economics, risk aversive safety nets, and markets for inputs and products
- development of a framework to help farmers understand the technology

B. Porter, social marketing, identified:

- institutional requirements for sustainability
- rapid implementation
- identification of local labor practices to develop a product mix to effectively use labor
- risk aversion

J. Thompson, institutional, identified:

- incentives for adoption, including a local capacity to structure new rules to allow and encourage adoption of the new technology and to continue to serve it
- ready and sustained availability of local and imported technologies to support the technology system
- economic considerations, including available institutions to support the new technology and markets for its products
- property rights that favor the adoption of a new technology

D. Osburn, agriculture, identified:

- availability of markets for inputs and products
- knowledge of the public and private farmer information-gathering and decision-making process
- existence of information systems to serve farmers.

CONCLUDING REMARKS

Moderator: Dr. H. Ray

In a brief concluding session, Ray solicited general remarks about the day's activities and regarding the Africa technology identification survey.

E. Chetwynd emphasized that the CTTA mass communication project must have good agricultural technologies to transfer to farmers and that every effort must be made to identify technologies that are in that context foolproof. At the same time, he questioned the availability of ready and appropriate agricultural technologies for transfer to African farmers.

J. Axtell emphasized the necessity of local research capability, and commented that national agricultural research staffs have developed many technologies for appropriate for local situations, but that they are generally frustrated with extension services and their apparent inability to communicate technologies to the farmer.

Possible technologies to be examined in the context of the survey include: technology for erosion control and water conservation; the International Institute of Tropical Agriculture cassava research, particularly in disease and insect resistance, and including biocontrol measures;

C. Martin suggested the survey countries might be chosen from those African countries categorized by AID as technology producing. From the four ecological zones of Africa they are: Cameroon, Kenya, Malawi, Senegal, Sudan, Zambia, Zaire, and Zimbabwe.

K. Swanberg asked that the framework, in addition to identifying technologies, consider how those technologies identified as future technologies might be moved to ready technologies.

K. Prussner suggested that the survey framework consider questions from the country USAID Mission level, including:

- What kinds of technology is the country ready for and wanting?
- How does the local Mission approach technology dissemination and diffusion?
- What are the benefits of participating in a communication project?
- Consider the mandate of local Mission activities.

A. Meyer concluded the discussion by asking that participants, synthesis panel members, and members of the agricultural technology survey team remember the ultimate purpose of the tasks -- to improve the quality of life of people.

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In closing the meeting, Ray thanked the participants for their excellent contributions toward developing a framework for the Agricultural Technology Survey, and suggested that participants might contribute additional thoughts about agricultural technology analysis, the survey framework, and appropriate countries to be included in the survey by the following week. The notes from today's meeting and those suggestions will then form a basis by which the Synthesis Panel will devise a final framework for use in the survey. A meeting of the Synthesis panel was scheduled at the Academy for Educational Development for 3 September 1986.

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AGENDA

PLANNING MEETING FOR AGRICULTURAL TECHNOLOGY SYSTEMS IDENTIFICATION FOR AFRICA

Envoy Room, Embassy Square Hotel, Washington, D.C.
20 August 1986

8:00 - 8:30 Arrival and Coffee

8:30 - 9:00 PLENARY SESSION
Howard E. Ray, AED, CTTA Project Director, Conference Chairperson

Introductions
Anthony J. Meyer, CTTA Project Manager AID/S&T/ED, and Kenneth G. Swanberg, CTTA Project Co-Manager AID/S&T/RD

Purpose
Ruth Zagorin, Director, Office of Human Resources, AID/S&T/HR

Objectives
Howard E. Ray

9:00 - 10:30 TECHNOLOGY I - Drought Resistant Crops

Moderator
David Thurston, Plant Pathology Department, Cornell University

Technology Presenter
Raymond Meyer, Soil Scientist, AID/S&T/AGR

10:30 - 10:45 Break

10:45 - 12:30 TECHNOLOGY II - Response Farming (Water Management)

Moderator
Kenneth Prussner, Chief, Agriculture and Rural Development, AID/AFR/TR/ARD

Technology Presenter
Ian Stewart, Agro-meteorologist, AID/ANE/TR/ARD

12:30 - 1:45 Lunch

1:45 - 3:45 TECHNOLOGY III - Alley Cropping

Moderator
Kenneth G. Swanberg

Technology Presenter
Calvin Martin, Assistant Director, Office of Technical Resources, AID/AFR/TR

3:45 - 4:00 Break

4:00 - 5:00 PLENARY SESSION
Howard E. Ray

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Appendix 3

TEAM ITINERARY

APPENDIX 3

TEAM ITINERARY

(31 October -- 27 November, 1988)

31 October	Leave Washington for Dakar
2 November	W. Nilsestuen, Chief ADO/AID Dr. Ndiaga Mbaye, Acting Director/ISRA Dr. Jean-Pierre Dennis, Director/UNIVAL Dr. Jacques Faye, Consultant
3 November	Dr. Jean-Pierre Dennis Dr. J. Faye Dr. Benjamin Diouf, Director/SODEVA
4 November	M. Mody Ba, Maize breeder/ISRA Dr. Papa Camara, President, Maize Breeders Association/ISRA M. Guy Pocthier, CIRAD
5 November	M. Papa Leopold Sarr, Director, Recherches Systemes Agraire et l'Economie Agricole/ISRA M. James Bonner, ADO/AID
6 November	Visit to on-farm research/ISRA, Kaolack M. Samba Diallo, Delegue Regional/SODEVA M. Patrice Garin, Agronomist/ISRA M. Desire Sarr, Sociologue/ISRA
7 November	Visit to Kaymor region, ISRA research sites
9 November	Visit to Bambey/ISRA research station Dr. Mamadou Somko, Director/ISRA/Bambey Station M. Demba Farba M'Baye, Pathologist/ISRA M. Amadou Bocar Baal, Entomologist/ISRA
10 November	M. Doral Watts, ADO/AID Dr. Khoi Le, Irrigation Agronomist/AID Dr. Francis Can, Research & Extensions Coordinator/AID Dr. Francois Faye, Director, Recherches Production Vegetales/ISRA Dr. M'Baye N'Doye
11 November	Scheduled meetings cancelled
12 November	Write up
13 November	Debriefing/AID

Mlle. Sara Jane Littlefield, Mission Director

M. W. Nilsestuen
M. Doyle Watts
Dr. Khoi Le
M. Gil Haycor
M. Terry Myers

Debriefing/ISRA

Dr. Papa Camara
Dr. Jean-Pierre Denis

14 November	Leave Dakar for Niamey
16 November	M. Marc Madland, ADO/AID Dr. Ronald Gibbons, Director/ICRISAT Dr. Ken Koehn, NDD/AID M. John Mullinex, APS/AID
17 November	M. Ernest Gibson, Senior ADO/AID M. Marc Madland, ADO/AID M. Quincy Benbow, ADO/AID Dr. Frederick Sowers, APS/AID Dr. Gonzalo Romero, APS/AID M. Dennis Panther, ADO/AID
18 November	M. Flynn Fuller, ADO/AID Dr. John Clark, NCR/AID Dr. Chandra Reddy, NCR/AID M. John Lameris, APS/AID
19 November	Dr. Charles Renard, Agronomist/ICRISAT M. Phil Serafini, Farm Manager/ICRISAT Dr. Okiror, Plant Breeder/ICRISAT Dr. Bonny Ntare, Agronomist/ICRISAT
20 November	Visit to Guesselbodi Forest M. Gary Minnick, Forester
23 November	Visit to N'Dounga Machinery Site M. Roman Imboden Dr. Idrissa Soumana, Director/INRAN
24 November	Write up
25 November	Debriefing/AID M. George Eaton, Mission Director M. Coulter, Deputy Mission Director M. Kevin Mullally, ADO M. Marc Madland, ADO
26 November	M. Salissou Aboubacar, Chef, Departement Socio-Economie, IPDR/Kolo

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	Commandant Anada Tiega, Director Adjoint, Eaux et Forets M. Soussou Mousse, Chef, Departement Formation/UNC
27 November	Leave Niamey for Washington

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Appendix 4

SENEGAL NATIONAL AGRICULTURAL RESEARCH SYSTEM

APPENDIX 4

SENEGAL NATIONAL AGRICULTURAL RESEARCH SYSTEM

A. Agricultural Research Institutions and Structure

The Institut Senegalais de Recherches Agricoles (ISRA), diagrammed in Figure 1, is the research arm of Senegal's Ministry of Rural Development (MDR). The Institute's Director General and Deputy Director General supervise research in crops, animal production and health, aquaculture, and forestry.

ISRA has no extension functions--extension responsibilities have been delegated primarily to regional development authorities, some of which have since been or will be eliminated by the New Agricultural Policy (NAP) (57*). Agricultural inspectors, responsible for seed and fertilizer distribution, apparently also have some responsibility for extension (4).

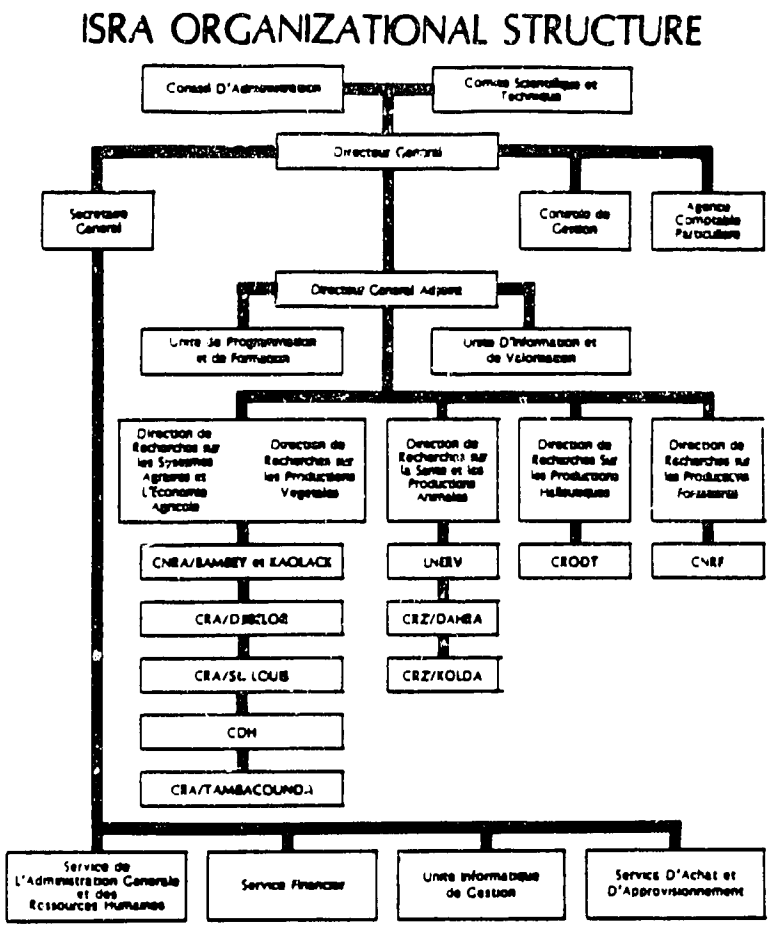

Figure 1
ISRA Organizational Structure

* See Section III.E for literature citation.

Although personnel and agencies responsible for extending agricultural information exist, virtually all who were interviewed by the assessment team identified extension's present structure and performance as a major constraint to technology transfer.

Under NAP, developed in 1984, Senegal is encouraging greater private sector participation in the production and marketing of agricultural commodities and related inputs, and is reducing or eliminating the government's role in these areas (disengagement). As a result of disengagement, some parastatal regional authorities were liquidated in 1985, and the remaining regional development agencies signed performance contracts that limit their role primarily to planning and extension services.

Under the NAP, the government remains responsible for "planning, extension information, research, and monitoring functions which complement private sector production and marketing activities and are government's legitimate province" (57).

The discussion which follows will emphasize the role of the crops research unit and its relationship to the supporting information units.

Approximately 180 scientists are involved in cereals research (9). The ISRA "Direction de Recherches sur les Systemes Agraire et l'Economie Agricole" is responsible for farming systems and on-farm research, and the "Direction de Recherches Sur Les Productions Vegetales" conducts on-station research.

The Program and Training, and Information and Valorisation, units have the potential to play strong communication and coordination roles in strengthening the ability of the system to transfer agricultural technology to farmers. The program and training unit that works across all program areas (9) could fulfill a valuable function in improving communication for technology transfer through staff development and training, and by developing research programs relevant to needs of Senegalese farmers.

The Information and Valorisation Unit (UNIVAL) may have the most potentially valuable role in communication for technology transfer. UNIVAL has access to all research units, and is responsible for collecting results for the entire research system. Researchers said they expect this unit to disseminate research results.

As shown in Figure 2, UNIVAL has three sections -- Documentation, Publication, and Valorisation. The Documentation Section receives and archives information from research scientists. Each major research program unit has a department of documentation with at least one person responsible for recording research results and sending them, each quarter, to the central unit.

UNIVAL collects information from scientists within the system and

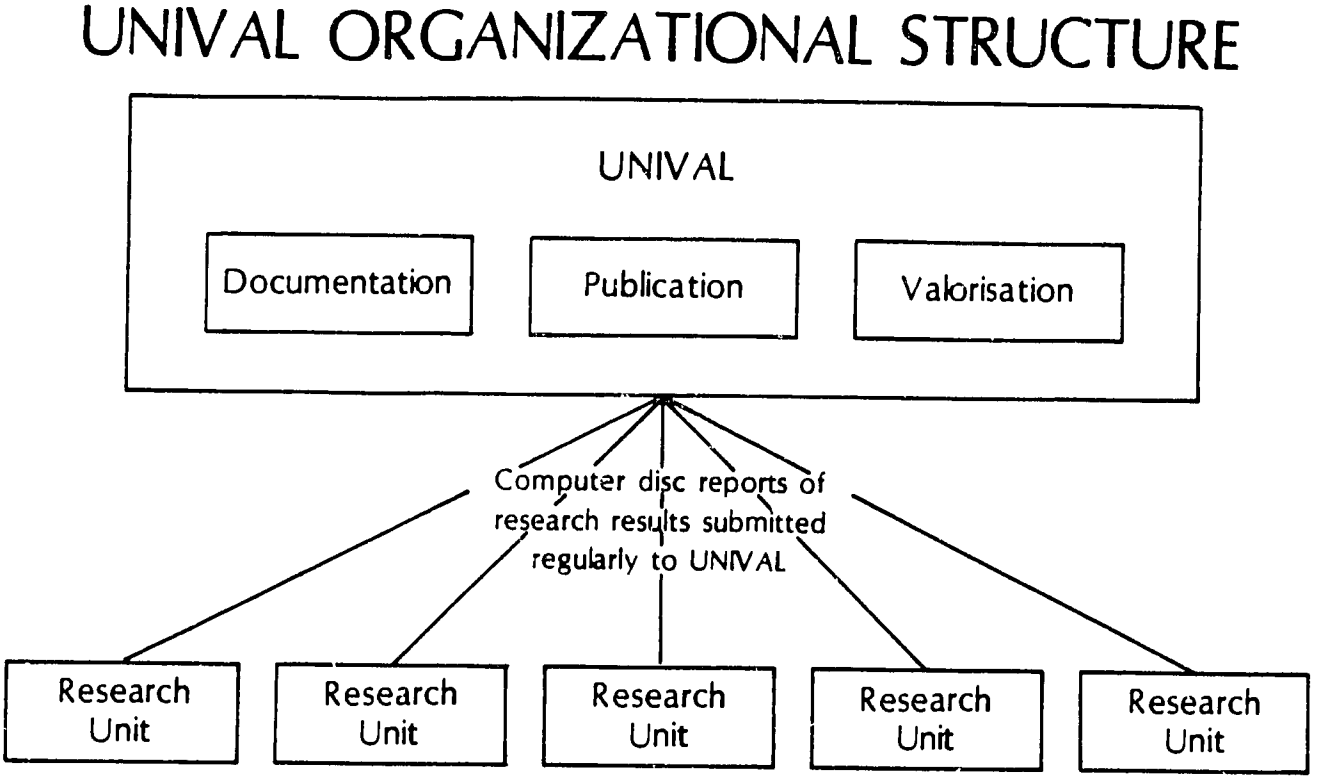

Figure 2

UNIVAL Organizational Structure

related regional and international research programs, and produces information sheets summarizing research results for circulation to researchers within and outside the system (9). The unit also produces an analytical bulletin and fills requests for copies, annotated bibliographies, and index bibliographies.

The Publications Section irregularly publishes a 150-page journal for SODEVA and other extension entities and a "cahiers d'information" series for extension agents and farmers. It also produces special publications and studies with specific research orientations.

The Valorisation section (intended to give or add value to the information) has not been established, but great need was indicated in this area. It was indicated that there is substantial potential for providing better information to extension workers and farmers, through mass media (newspaper, radio, and television); establishing slide, tape library, and photo libraries; developing exhibits for meetings; and developing newsletters.

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B. Linkages With Regional and International Research Programs

There are several development programs being conducted in Senegal by organizations from other nations, including: ADRAO (Association pour le Developpement de la Riziculture en Afrique de l'Ouest), AVRDC (Asian Vegetable Research and Development Center), CEEMAT (Centre d'Etudes et d'Experimentation du Machinisme Agricole Tropical [France]), CIRAD (Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement), FAO (Food and Agriculture Organization of the United Nations), FIDA (Fonds International pour le Developpement Agricole), ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), IITA (International Institute for Tropical Agriculture, INRA (Institut National de la Recherche Agronomique [France]), IRAT (Institut de Recherches Agronomique Tropicales et des Cultures Vivrieres [France]), ORSTOM (Institut Francais de Recherche Scientifique pour le Developpement en Cooperation), USAID (United States Agency for International Development), and Projet Encouragement de la Culture du Mais (German).

Although there is exchange between personnel from different programs, apparently no purposeful linkage exists to facilitate sharing of research information among the organizations, or between the organizations and ISRA.

UNIVAL has made some effort to secure and document information from these development organizations for ISRA researchers; some Senegalese scientists travelled to Nigeria to study alley cropping; USAID has cooperated with FAO in a regional integrated pest management program; and there may be a communication link established between the new USAID Agricultural Production Support Project and the ISRA system. In general, however, the team found no formal structure of communication linkages between and among national, regional, and international programs.

Appendix 5

NIGER NATIONAL AGRICULTURAL RESEARCH SYSTEM

APPENDIX 5

NIGER NATIONAL AGRICULTURAL RESEARCH SYSTEM

A. Agricultural Research Institutions and Structure

The Institut National de Recherche Agricole du Niger (INRAN) is the agricultural research arm of Niger's Ministry of Agriculture and Environment. The Institute's location within the Ministry is shown in Figure 1 below.

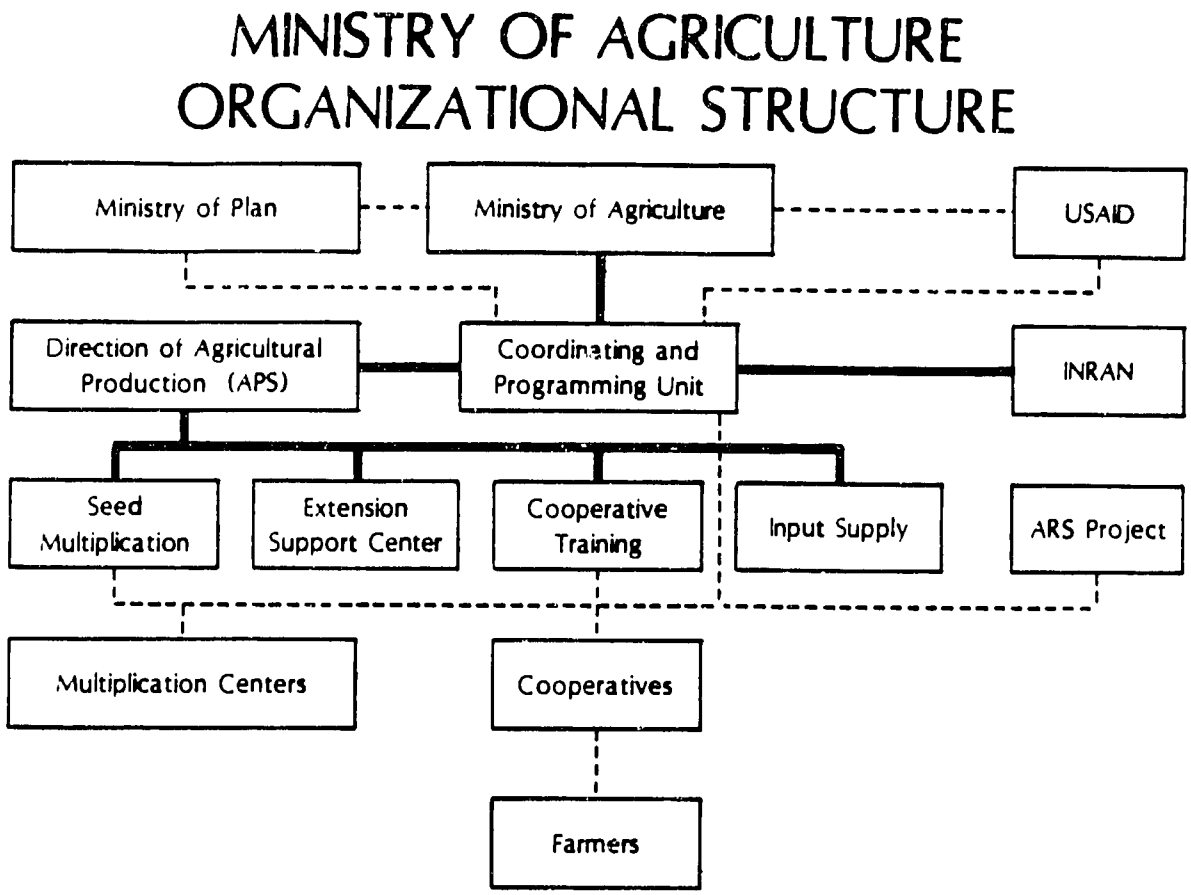

Figure 1

Ministry of Agriculture Organizational Structure

INRAN was established in 1975, and has been situated in the same ministry as the extension services since 1984. Organizationally, however, the Institute remains somewhat isolated from the rest of the Ministry. In addition, other ministries do research of interest to agriculture with little interaction with INRAN. Communication within and between ministries on common interests regarding agri-

culture poses a challenge.

INRAN and Extension responsibilities related to generation of agricultural technology (42*) are summarized in Figure 2. The extension arm of the ministry is expected to play a key role in multi-locational trials conducted by INRAN as well as to assume major responsibility for demonstration plots and village training.

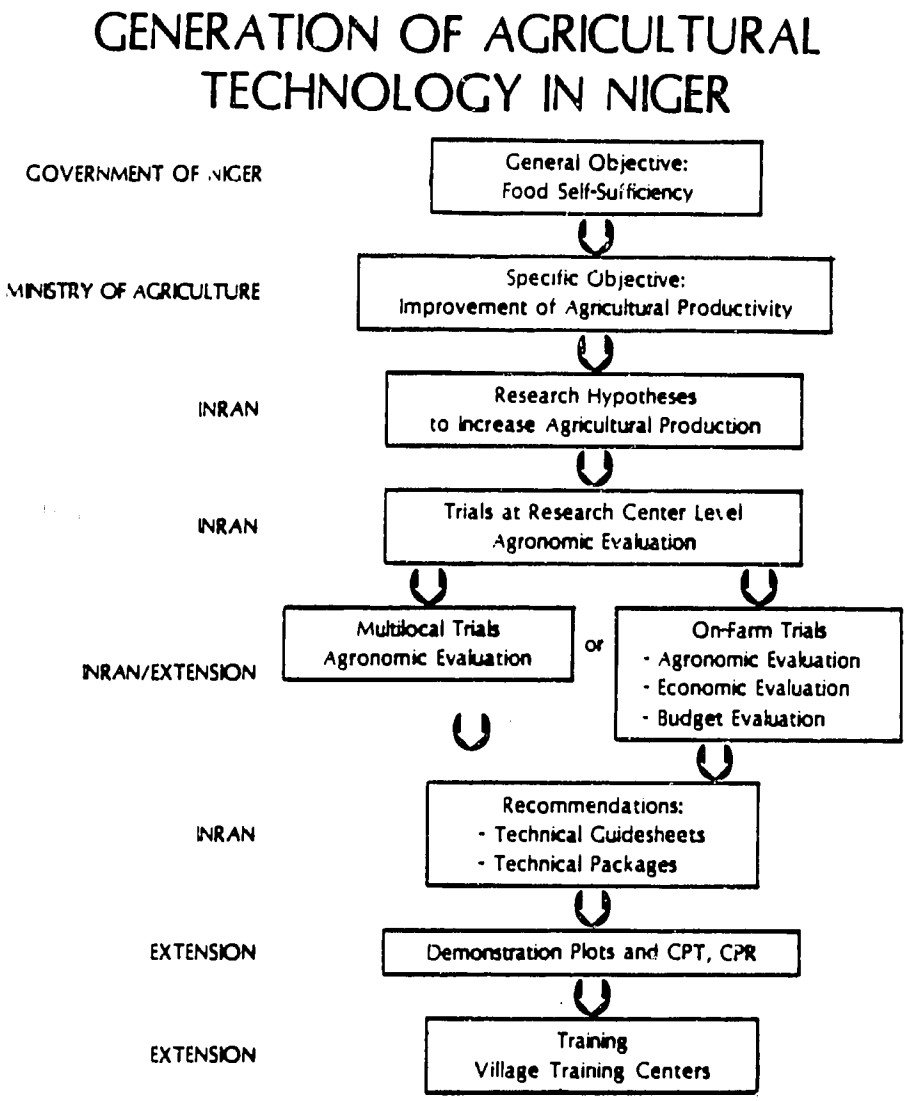

Figure 2

Generation of Agricultural Technology in Niger

A 1985 mid-term external review and evaluation of the USAID-sup-

[2] See text Section IV.E for literature citations.

ported Niger Cereals Research Project identified a number of constraints under which INRAN works, such as (35):

1) Insufficient critical resources;

2) Lack of support for scientists;

3) Substantial amounts of time spent by scientific personnel in administrative activities;

4) Insufficient interdisciplinary efforts between agronomy, animal husbandry, agricultural economics and forestry; and

5) INRAN research not focussed on site-specific environments.

This report indicates that "there is not a single agronomist, even at the BS level, in the entire institute." (35) Numerous sources were queried, however, to assess INRAN's capability to do adequate research; and positive responses were received from ICRISAT (8) and USAID personnel. (1, 3) A rough draft of the USAID evaluation report for the Agricultural Production Support Project (APS), November 1987, states: "There has been a sufficient flow of useful and adaptable information from the research program". (27)

INRAN is placing greater emphasis on farming systems research. The 1985 NCR evaluation indicates the Institute's focus to be a "production systems research program which will develop systems of cultural practices appropriate for production of cereals in the various ecological regions and by the various kinds of farm enterprises. Work will focus on the development of recommendations for intercropping, fertilizer use, time of planting, density and spacing, weeding and pest control, and similar concerns, including cost/return and related management analysis." (35)

B. Linkages with Regional and International Research Programs

Interviews with ICRISAT and NDD (Niamey Department Development Project) personnel, and others, revealed that much information exchange occurs between the national and international research programs. Although no specific linkage structures or processes were identified, there is evidence that considerable informal interchange occurs.(2, 3, 4, 5, 8, 9, 10, 16)

In addition, USAID cooperates with a regional meteorology program, and a USAID project officer serves as liaison between this program and INRAN/USAID project researchers.

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IDENTIFICATION AND ASSESSMENT OF STAGE OF READINESS FOR DIFFUSION TO FARMERS OF AGRICULTURAL TECHNOLOGIES AND TECHNOLOGY SYSTEMS IN SENEGAL AND NIGER

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Robert H. Brandstetter
Howard E. Ray
Edwin A. Tout

May 1988

Communication for Technology Transfer in Agriculture
(A.I.D./S&T 936-5826)

AED

COMMUNICATION FOR TECHNOLOGY TRANSFER IN AGRICULTURE PROJECT
(AID/S&T 936-5826)

Identification and Assessment of Stage of Readiness for Diffusion to Farmers of Agricultural Technologies and Technology Systems in Senegal and Niger

May 1988

By

Technology Assessment Team

David J. Miller
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Robert H. Brandstetter

CTTA Project

Howard E. Ray
Edwin A. Tout

The Communication for Technology Transfer in Agriculture (CTTA) Project is jointly managed and funded by the Offices of Education, Agriculture, and Rural Development of the Bureau for Science and Technology of the United States Agency for International Development in collaboration with Regional Bureau Technical Staff and the USAID Mission at each collaborating site. Technical services are provided by the Academy for Educational Development under Contract No. DPE-5826-C-00-5054-00.

The Technology Assessment Team acknowledges the assistance and co-operation received in Senegal and Niger from USAID and Host Country officials and staff; with special thanks to Jacques Faye, Jean-Pierre Denis, and Mawa Diop in Senegal, and Kevin Mullally and Marc Madland in Niger, for their in-country assistance in preparing this report.

EXECUTIVE SUMMARY

An agricultural technology identification and assessment field study was conducted in Senegal and Niger in November 1987 by a Communication for Technology Transfer in Agriculture (CTTA) Project consultant team. The activity, supervised by the CTTA Project Director, was made possible by a grant from the A.I.D. Bureau for Science and Technology.

The purpose was to survey new and underutilized agricultural technologies appropriate for farmers in selected African countries that are available from national, international, and regional research institutions. Specific objectives were to:

- identify and categorize technologies in each country that are ready or almost ready for diffusion to farmers, or that are promising for the future; and

- make recommendations for improving diffusion to farmers of ready and almost ready technologies.

In evaluating the technologies identified, the team assigned a "ready" classification if it appeared that the technology could be adopted immediately and beneficially by farmers. An "almost ready" category was assigned where it appeared that some adaptive research was needed and/or moderate institutional or other constraints would have to be alleviated before the technology could be recommended without reservation to farmers. "Promising" technologies were those that appeared to need substantive research and/or institutional modification before farmers could adopt and use them beneficially. In developing recommendations for improving diffusion to farmers, the team focused on working through existing institutions to the maximum extent possible.

Agricultural, institutional, and socioeconomic constraints were considered to be critical in determining the stage of readiness of a technology for diffusion. The range of factors involved, and the objective of developing recommendations for improving diffusion, made a multi-disciplinary field study team essential. Therefore, it was comprised of an agricultural technologist, an extension and communication specialist, and a rural sociologist.

The investigation in each country focused on rainfed cereal crop production. Technologies identified and assessed in Senegal were grouped into five technology sets plus five areas of technology-related observation. Eight sets were identified and assessed in Niger. The technologies and assessments of each as to stage of readiness for diffusion to farmers may be summarized as follows:

Senegal

1.	*	Using improved seed
2.	*	Increasing soil fertility
3.	*	Improving soil management and tillage
4.	*	Optimizing seed placement and row spacing
5.	*	Improving pest control
6a.	*	Improving timeliness of operations
6b.		Response farming
6c.	*	Introducing new crops
6d.		Alley cropping
6e.	*	Exploiting the rotation effect

Niger

1.		Phosphate (P) fertilization
2.	*	Improved multiple cropping
3.		Using animal traction
4.		Implement tillage
5.	**	Forage production
6.		Weather-responsive crop management
7.	**	Striga control
8.	*	Water harvesting

* : Technology (or component thereof) assessed as ready
** : Technology (or component thereof) assessed as almost ready

A commonality of the selected technologies is that they do not, for the most part, represent technological advances per se. Rather, they consist primarily of adjustments in fundamental aspects of field management or improvements in basic, often already existing, farming practices. Advanced technologies, such as applying commercially mixed fertilizers or using mechanized equipment, will remain inappropriate for most of Senegal and Niger until the more basic elements of management, such as reducing soil erosion and using quality seed, are implemented.

The limited information farmers receive about their basic management practices is seldom adapted to their circumstances. For example, crop management recommendations are uniform for the entire country. To overcome such problems, farmer-research-extension linkages and the agricultural extension system need to be strengthened. The strengthening process should include:

- identifying problems that limit production in each extension agent's local area;
- establishing an effective two-way farmer-research-extension communication system;
- assembling information pertaining to the problem's solution and/or outlining research needed to provide the information;

- establishing locally-customized on-farm trials designed to demonstrate management needed to overcome the problem;
- training agents as communicators and educators;
- integrating the use of mass media and other channels into the conventional extension dissemination methodology.

As indicated throughout the report, more research -- particularly to localize recommendations -- will be needed, and there is urgent need to strengthen and modernize extension services to farmers. Even if both are accomplished, however, significant (in some cases, absolute) constraints to widespread farmer adoption of improved agricultural technologies will likely remain unless some parallel action is initiated to alleviate them. These include institutional factors such as lack of credit, inadequate delivery systems, insufficient support industries, undeveloped markets, etc.; and socio-economic factors such as input costs, social and cultural obligations, price policies, and so on.

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GLOSSARY OF TERMS AND ACRONYMS

GENERAL

AED	-	Academy for Educational Development
AID, A.I.D.	-	Agency for International Development of the Government of the United States
AID/S&T	-	The Bureau for Science and Technology of AID
AID/S&T/ED	-	Office of Education of S&T
AID/S&T/RD	-	Office of Rural and Institutional Development of S&T
APS	-	Agricultural Production Support Project
cm	-	centimeters; 100 cm = 1 m
CTTA	-	Communication for Technology Transfer in Agriculture Project
ha	-	hectares; 1 ha = 2.47 acres
ICRISAT	-	International Crops Research Institute for the Semi-Arid Tropics
IITA	-	International Institute of Tropical Agriculture
K	-	potassium
kg	-	kilograms; 1 kg = 2.2 pounds
m	-	meters; 1 m = 39.37 inches
N	-	nitrogen
NGO	-	Non-Governmental Organization
P	-	phosphorus, phosphate, phosphatic
PID	-	Project Identification Document
pH	-	a measure of acidity or alkalinity (a low pH soil is acidic)
PVO	-	Private Voluntary Organization
USAID	-	United States Agency for International Development Mission to a country

SENEGAL

ADRAO	-	Association pour le Développement de la Riziculture en Afrique de l'Ouest (Rice Culture Development Association)
AMRA	-	Association of Maize Researchers in Africa
CEEMAT	-	Centre d'Etudes et d'Expérimentation du Machinisme Agricole Tropical (France) (Center for Study and Experimentation and Tropical Machinery)
CIRAD	-	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (France) (Center for International Cooperation in Agronomic Research)
Couscous	-	a dish for which steamed crushed grain is the basic ingredient
CSRA	-	Centre National Recherche Agronomique (National Agronomic Research Center)
DPCS	-	Direction de la Production du Controle des Semenses (Seed Production and Control)
FAO	-	Food and Agriculture Organization (United Nations)
FIDA	-	Fonds International pour le Développement Agricole (International Agricultural Development Fund)
GOS	-	Government of Senegal
ICARDA	-	International Center for Agricultural Research in Dry Areas
INRA	-	Institut National de la Recherche Agronomique (France) (National Institute for Agronomic Research)
IRAT	-	Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières (France) (French Institute for Research on Tropical Food Crops)
ISRA	-	Institut Sénégalais de Recherches Agricoles (Senegalese Institute for Agricultural Research)
NAP	-	New Agricultural Policy
ORSTOM	-	Institut Français de Recherche Scientifique pour le Développement en Coopération (Office de la Recherche Scientifique et Technique Outre-Mer, avant 1985) (French Institute for Scientific Research for Cooperative Development)

SODEVA	-	Société de Développement et de Vulgarisation Agricole (Agency for Development and Agricultural Extension)
UNIVAL	-	Unité d'Information et de Valorisation (Information and Valorisation Unit)
USAID/S	-	United States Agency for International Development Mission to Senegal

<u>NIGER</u>

AGRHYMET	-	Sahel Water Data Management
ESC	-	Extension Support center
FSR/E	-	Farming Systems Research/Extension
INRAN	-	Institut National de Recherche Agricole du Niger (Nigerien National Agricultural Research Institute)
ISNAR	-	International Service for National Agricultural Research
NCR	-	National Cereals Research
NDDP	-	Niamey Department Development Project
ONAHA	-	(National Office for Irrigated Perimeters)
ORTN	-	(National Radio and Television Office)
USAID/N	-	United States Agency for International Development Mission to Niger
FLUP	-	(Forestry and Land Use Planning)
UNC	-	(National Cooperative Union)
IPDR	-	Institut Pratique de Developpement Rural

Communication for Technology Transfer in Agriculture (CTTA)
(AID/S&T Project 936-5826)

IDENTIFICATION AND ASSESSMENT OF STAGE OF READINESS FOR DIFFUSION TO FARMERS OF AGRICULTURAL TECHNOLOGIES AND TECHNOLOGY SYSTEMS IN SENEGAL AND NIGER *

Findings of a November 1987 CTTA consultancy to Senegal and Niger are reported herein. This report will be followed later in the year with findings from a related activity for which field work in Niger is planned in April and May 1988.

I. ACTIVITY DESCRIPTION

A. Activity Purpose

The purpose of the activity was to survey agricultural technologies appropriate for farmer-managed systems of mixed farmers in selected African countries that are available from national, international, and regional research institutions and programs, but that have not been adopted or are presently underutilized by those farmers.

The specific objective was to identify and categorize those technologies that are:

1) Ready for diffusion

   "Ready" technologies could be adopted immediately and beneficially by farmers within their own constraints and the existing institutional framework. It is presumed that lack of adoption to date is due primarily to lack of information, understanding, and/or motivation on the part of farmers for whom they would be appropriate.

2) Almost ready for diffusion

   "Almost ready" technologies have been proven technologically, but require some additional research to determine local adaptation and/or moderate modifications in institutions, institutional support and/or policies to enable farmers to adopt them beneficially. Technologies in this category were to be limited to those for which it is realistic to expect that they can be shifted to the "ready" category within two to four years.

* Supported primarily through incremental funding to AED Contract No. DPE-5826-C-00-5054-00 for technical services to the CTTA Project, received from AID/S&T.

In addition to the foregoing, technologies brought to the consultants' attention that appear promising for the future were to be noted and described in anecdotal form. "Promising" technologies will require substantive additional research and/or institutional modification before they can be adopted and used beneficially by farmers. In most cases, it would be unrealistic to expect them to be ready for widespread diffusion in less than four or five years at the minimum.

(In the context of this activity, the term "technologies" includes both single technologies and technology systems. A single technology is defined as a practice or input into a single enterprise (e.g., control measures for a given pest, an improved crop variety, or a seedbed preparation technique). A technology system is defined as a series of interrelated actions, practices, etc. (e.g., a farming system including mixed livestock/crop systems, alley cropping, or the complete production cycle for a given crop).)

The Activity Scope of Work also included providing recommendations for improving diffusion of ready and almost ready technologies.

B. Countries To Be Selected

The activity plan specified that up to four African countries would be selected for the study, with final selection dependent upon USAID Mission interest.

Due to funding constraints, it was possible to conduct the field study in only Senegal and Niger.

C. Activity Structure

Principal investigator for the activity was Howard E. Ray, PhD, CTTA Project Director.

The Activity Plan, including its analytical framework, is attached as Appendix 1. Its development started with the interdisciplinary planning meeting reported in Appendix 2. The analytical framework (Appendix A of Appendix 1) was developed in preliminary form by a small panel selected from planning meeting participants. The final plan was prepared by the Principal Investigator in consultation with the AID/S&T/ED CTTA Project Cognizant Technical Officer and AID/AFR/TR/ARD staff, and circulated to interested USAID Missions for their review.

Pre-departure preparation for the field study included extensive reviews of relevant documents, contacts with people and institutions familiar with the region and technology sources, and assembly of general information on Senegal and Niger for the study team's reference in the field. Consultants comprising the team received an intensive two-day orientation before departure to Africa.

The study was conducted by an interdisciplinary team of three senior scientists with extensive African experience, comprised of:

David J. Miller, PhD	-	Specialist in Extension and Communication, and Team Leader
R. Kent Crookston, PhD	-	Agronomist
Robert H. Brandstetter	-	Rural Sociologist

(The Principal Investigator did not join the field team due to his lack of fluency in French.)

The team itinerary is attached as Appendix 3, and activities in each country are discussed in Sections III.A and IV.A for Senegal and Niger.

The investigation in each country focused on rainfed cereal crop production.

Preliminary draft reports of in-country findings in each country were provided to the USAID Missions in Senegal and Niger. The present report was prepared in draft by the Field Team Leader, reviewed and revised by team members in consultation with CTTA professional staff, and circulated to appropriate AID Offices for review. The Principal Investigator participated in the review discussions and assumed responsibility for final drafting.

A seminar is tentatively planned for presentation and discussion of findings from this activity and the closely related activity discussed in Section I.E. Reports from both activities will be circulated to seminar participants ahead of the event.

D. Expected Outcomes

Major outcomes expected from the Activity are identified in Section VII of the Activity Plan (Appendix 1).

E. Related Africa Activity

A closely-related "Innovations" Activity*, being conducted in tandem with the present activity, focuses on the farmer as an innovator and experimenter. Its purpose is to establish the precise areas of needs and the potential role of communication in situations where standard technologies are not yet clearly evident or appropriate.

The working hypothesis underlying the Innovations activity is that the next most appropriate step in the technology transfer process in such situations may be the identification and diffusion of appropriate, ready and adaptable analytical skills and experimental process technologies for farmers, researchers, government agencies, private sector suppliers, etc., to improve the quality and quantity of their own innovation and adaptation of new technology processes

* Supported through incremental funding to AED Contract No. DPE-5826-C-00-5054-00 for technical services to the CTTA Project received from AID/S&T/RD.

(e.g., risk analysis, on-farm trials, genetic improvement, market analysis, etc.).

The Innovations Activity Coordinator (Robert H. Brandstetter) participated on the Technology Identification and Assessment Team to obtain background information for use in developing a plan for testing the above hypothesis in the field, in addition to contributing to the present study.

As of this writing, the plan for the second field activity is in the formative stages, being developed in consultation with representatives of the AID/S&T Offices of Rural Development, Education, and Agriculture, and with assistance of selected consultants and other people knowledgeable about the Sahel.

A followup investigation in Niger by the Innovation Activity Coordinator and another consultant is planned for April-May 1988. That study is expected to provide the basis for developing a model for a farmer-oriented, communication-based, technology transfer system specifically applicable to Niger and generally applicable to the Sahel.

As indicated earlier, the results of the Innovation Activity will be presented and discussed during a one-day seminar in conjunction with results of the present Activity.

II. GENERAL CONCLUSIONS

Some technologies identified in the report are specific to Senegal or Niger, or to ecological zones within each country. Some striking similarities were also found, however, particularly with regard to basic management principles. A similar situation was found with respect to the diffusion process.

A. Technologies

Three conclusions, common to both countries, are of overriding importance:

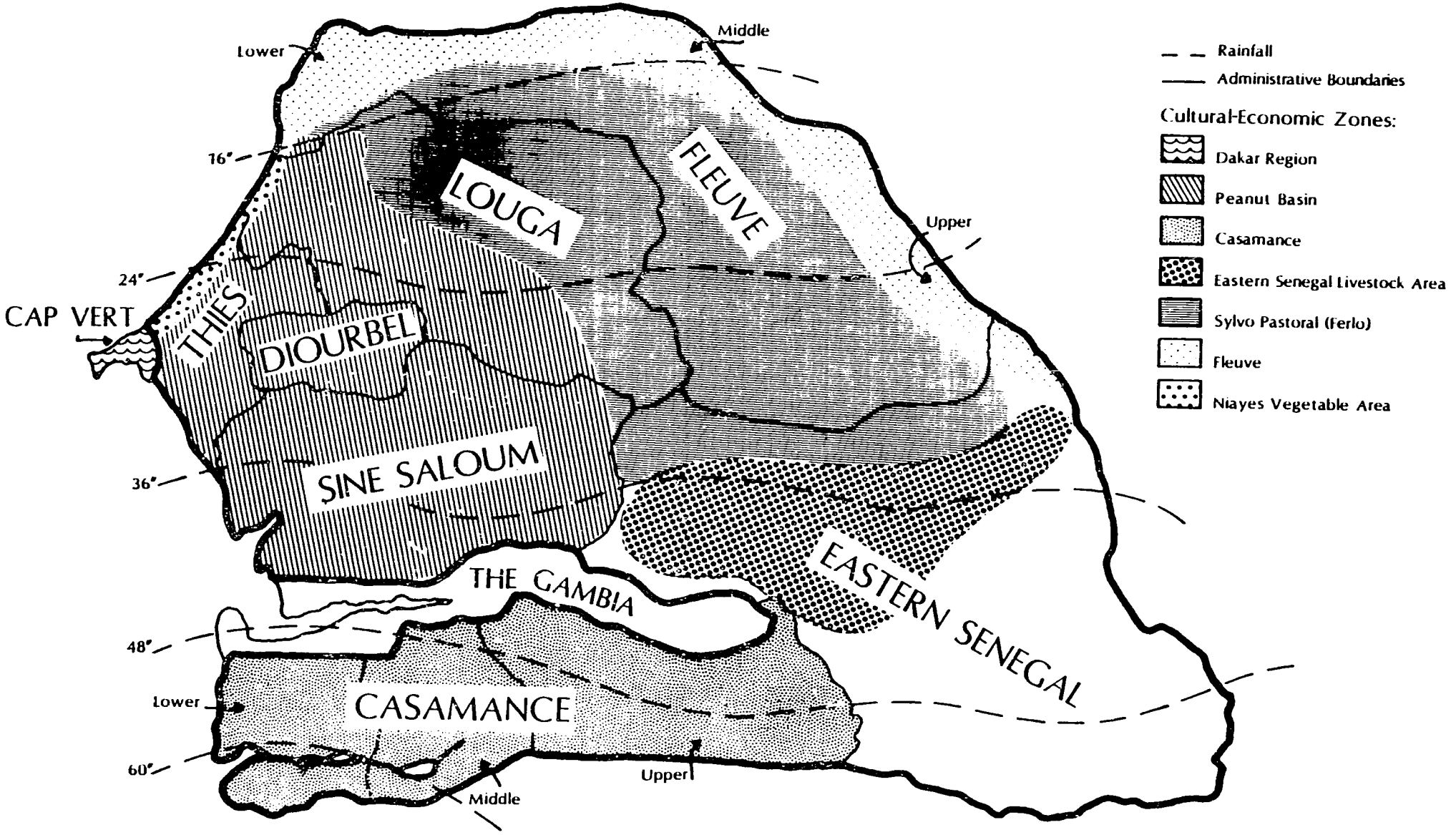
- Alleviation of present farmer management knowledge and practice constraints is needed to secure widespread adoption of improved technologies.
- Widespread adoption by farmers of technologies available from research is at present seriously constrained by institutional, infrastructural, and socioeconomic factors.
- With few exceptions, localized recommendations for use of the technologies are not available. Present recommendations are uniform for the entire country.

B. Diffusion

The following conclusions, also common to both countries, are of particular importance:

- Existing linkages and information flow between Research and Extension are inadequate, and must be strengthened if Extension is to support farmers with relevant, useful information on the use and management of new technologies.
- If integrated into the technology transfer program, mass media have high potential for creating farmer awareness of and interest in the use and management of improved technologies, and for supplementing traditional extension methods.
- Extension agents generally lack the understanding and skills, and the steady flow of reliable information, needed to perform the educational role essential for working effectively with farmers.
- Extension effectiveness is presently seriously hindered by lack of support to diagnose local situations and needs, and to localize research information to the needs of individual farmers.

ADMINISTRATIVE BOUNDARIES - CULTURAL-ECONOMIC ZONES - RAINFALL



III. TECHNOLOGY IDENTIFICATION AND ASSESSMENT

SENEGAL

The technology identification and assessment investigation for Senegal, limited primarily to rainfed cereals, was conducted 1-14 November 1987. The CTTA consultant team collaborated closely with national counterparts from ISRA (Institut Senegalais de Recherches Agricoles), and in consultation with USAID/S.

Results of the study are organized into five major technology sets and five technology-related observations and recommendations.

A. Background

In confirming its interest in collaborating in the Assessment through its cable of 9/18/87 (62), USAID/Senegal:

- requested that the focus be on cereals and cereal-related technologies (rice, sorghum, millet, corn, and cowpea), with forestry included as time permitted;

- proposed Dr. Jean-Pierre Denis, Principal Coordinator of the Information Unit (UNIVAL) within ISRA (Senegalese Institute for Agricultural Research), as principal coordinator; Dr. Jacques Faye, until recently Director of the ISRA Production Systems and Applied Economics Department, to assist; and involvement of ISRA research scientists and knowledgeable staff of the regional development authorities;

- requested that the CTTA team spend two weeks in Senegal analyzing the needs of ISRA and USAID, stating, "We concur with the four proposed outputs of the assessment as detailed Ref 8, part 1, page 3, as Mission hopes to use results in planning new Ag Research Project, and ISRA is seeking to develop a strategy for improving effectiveness of technology transfer. We wish to emphasize that results need to be relevant to our respective needs, and timely."; and

- indicated that, in anticipation of the down-stream implications of this assessment, the Mission was interested in possible follow-on assistance from the CTTA Project, and under what terms.

In his initial briefing to the CTTA team on 2 November, Mr. Wayne Nilsestuen (1), Chief, Agricultural Development Office, USAID/S, re-emphasized that the Mission was primarily interested in technology related to cereals. He identified two major Mission concerns associated with the team's activities. First, the Mission wanted

to know what there is to show for all the years of support to agricultural research (essentially an inventory of technologies available). Second, the Mission hoped to use results of the team's study in developing the PID (Project Identification Document) for a new project being planned with ISRA to focus on the interface between research and extension.

The assessment and recommendations presented and discussed herein are based on

- study of relevant documents;
- interviews with key administrators and scientists at national and international levels;
- discussions with scientists, village leaders, and farmers at regional and village levels;
- observations from field trips to the Kaolack and Bambey areas, and farm visits;
- interaction with USAID staff, team colleagues from ISRA, and representatives of other international development organizations; and
- experience of the consultants with agricultural research and technology transfer programs and with International Agricultural Research Center programs in Africa, Asia, and Latin America.

Information and opinions received from the persons interviewed, and the team's observations, are discussed and summarized in a manner conducive to drawing conclusions and consensus as to technologies available and constraints to adoption. Due to time and logistical constraints, however, much of what is reported is impressionistic.

The team's schedule (Appendix 3) was arranged largely by Mr. Mawa Diop, USAID Assistant Project Officer, as Dr. Denis, ISRA Coordinator for the study, was unavailable from 4 to 11 November. Principal contacts made and references reviewed are listed in Section III.E.

B. Agricultural Technology Assessment

Senegalese agriculture depends primarily on dryland crops. Of 2.4 million cultivated hectares in Senegal, approximately 47 percent are in peanut; 44 percent in millet/sorghum; 3 percent in rice and 2 percent each in maize, cotton, and cowpea. There is also limited production of fruits and vegetables near urban areas.

Senegal imports more than 50 percent of its cereals. Thus the government is encouraging a major effort to expand production of cereal crops, with the goal of producing 80 percent of the nation's food requirements by 2000 (1, 50).

Rainfed crops represent 90 percent of total agricultural production

and about 90 percent of domestic cereals. Sixty percent of the potential arable land is in the peanut basin. Irrigation presently serves less than 1 percent of arable land. The pressure on the land, already severe, is intensifying. By 2010, Senegal must double cereal production to meet requirements of population growth. (1, 57)

Assessment of the stage of readiness for diffusion to Senegalese farmers of new or underutilized technologies involves not only ecological and present crop distribution factors, and the country's need for increased food production. It also requires consideration of several other factors, any one of which may place an absolute or near absolute constraint on widespread farmer adoption. Among these are:

- local adaptation
- infrastructural/institutional constraints
- socioeconomic constraints
- government policies

The practicality of a given technology for farmers in a region (although it may have been tested on farms, and proven to be locally adapted and potentially beneficial) depends also, for example, on farmer access to credit, inputs, and markets. Input/price relationships affect its economic viability. And government policies may be either incentives or disincentives for adoption.

Consistent with the Mission's interest, the investigation was limited to identification and assessment of technologies related to rainfed cereals. Insofar as time permitted, the identified technologies were separated into individual components, each of which was then categorized as being "ready," "almost ready," or "promising" for diffusion to farmers (as defined in Section I.A).

The investigation revealed that several of the technologies assessed as having few agricultural constraints nevertheless faced formidable institutional and socioeconomic constraints. Furthermore, improvements in basic production/management practices will be required to permit their effective use.

The five technology sets and five areas of technology-related observation identified by the team are described and discussed below.

1. Using improved seed

a. Problem addressed

A frequent comment associated with poor crop performance in Senegal was "the seed was bad." Most farmers were aware of the existence of improved seed (some said they would steal to obtain it), but they did not appear to differentiate between improved quality of the seed per se (i.e., vigor and germinability) versus the genetic potential of varieties grown from the seed.

b. Description and source

This technology consists of making a ready supply of quality seed available to farmers. Two distinct types of quality are implied. The first, seed quality, involves seed stamina. The second, varietal quality, involves the nature of the plant that develops from a seed. An improved variety is genetically programmed to respond favorably to the circumstances under which it is grown.

Most Senegalese farmers maintain their own local varieties that, although quite well adapted to their ecological conditions and current production practices, lack yield potential and do not respond well to improved management or adequate rainfall. Not only are farmers limited to growing their own unimproved varieties, but they lack a reliable means of assuring the quality of the seed they maintain.

An ideal solution to the problem of "poor seed" would be to establish a public or private seed development and distribution program that would assure a supply of quality seed of improved varieties to all farmers.

Seed quality. Farmers should be informed as to how to best select, collect, and store their own seed from their own fields. There is little chance that this will improve the genetic makeup of their varieties beyond what would occur naturally, but the quality of seed that is carefully chosen and stored will likely be much greater than the quality of seed that is merely rescued from unselected stocks otherwise destined for food or feed. Scientists and good farmers in Senegal already have the information needed (methodology) for preserving on-farm seed quality. The technology is therefore ready for diffusion.

Varietal quality. Changes or gains in genetic composition necessitate trained personnel. Depending upon the crop, improved varieties are available from ISRA in Senegal and from regional and international agricultural research centers. Widespread use of these varieties will require a large pool of personnel trained in seed stock maintenance and certification and a seed storage and delivery system. Although it remains largely beyond the resources of Senegal, development of this technology is recommended and

classed as promising, as it would improve productivity.

Major sources of this technology include international, regional, national and local agricultural research centers and programs, plus present practices of progressive Senegalese farmers.

c. Stage of readiness for diffusion to farmers

Stages of readiness for the several components of this technology are summarized in Table 1 below.

Table 1

Stages of readiness for diffusion to farmers of technologies for increased use of improved seed. (Senegal)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
1) Improved seed quality			
Farmer grown	X		
Private or publicly developed			X
2) Improved varietal quality			X

* Depending on the crop, private and publicly-developed seed and improved varieties are available on a limited basis in Senegal. Stage of readiness for these technology components considers widespread use.

Opportunities for production increases through better preservation of seed and use of improved varieties exist for virtually all ecological zones and farmers of Senegal.

d. Potential benefits and negative consequences

Using quality seed of local varieties or hybrids was reported to have the potential of increasing corn yields from 10 to 300 percent, respectively.

When environment and/or management inputs are poor, improved and unimproved varieties generally yield about the same. Under favorable environments and intensified management, however, improved varieties usually yield better--often much better--than traditional varieties.

On the negative side, introducing hybrids and composites would require farmers to purchase rather than grow their seed, thus increasing production costs. Replacing local varieties with hybrids or improved open-pollinated stock would introduce an initial level of

risk in the form of dependence on technology to provide the favorable environment needed to recover the cost of purchasing such seed. Also, converting to improved varieties could result in losing valuable genetic diversity that is normally maintained by farmers in the form of their own local varieties.

e. Constraints to increased farmer adoption

Agricultural:

* Although the ability to deliver this technology exists in Senegal on a limited basis, the ability to receive and implement it is largely missing. Major increases in production will result from adoption of better agronomic practices. Efforts to obtain and distribute better varieties will be virtually wasted unless management practices are first improved.

Institutional:

* Variety development is still experimental in Senegal. Private seed companies have only recently begun to inquire about entering the country. Improved composites are virtually unknown to farmers. Although a start has been made, there is no major program to improve local varieties.

* Farmer demand for improved seed appears to be strong, but there is great uncertainty about availability. During the transition from government-provided seed to the private sector providing seed, the biggest constraint may be availability.

* An educational program will be needed to acquaint farmers with the management needed to benefit from using improved seed. It would be very difficult to diffuse information about a new variety without a trained and prepared extension staff and well organized program.

Socioeconomic:

* Both financial and time costs needed to train extension personnel, and the cost of developing an educational package, are economic constraints within the institutions involved.

* The necessity to purchase seed of improved varieties or hybrids, and other inputs needed to take advantage of the seed's genetic potential, may increase the farmers' credit needs. Credit is usually not available to all farmers.

f. Issues for further consideration

* There is general agreement among agricultural scientists in Senegal, and across the Sahel, that increasing corn production is important to regional self-sufficiency in cereals. Special effort should be made to promote and improve production of this crop that

currently occupies two percent of Senegal's cultivated hectarage.

* Like corn, cowpea currently occupies only 2 percent of Senegal's cultivated hectarage. During the drought of the 70s, sorghum and millet crops failed, and cowpea became the crop of security, producing enough grain to enable people to survive. In addition to being a food crop, cowpea also provides valuable fodder for animals, and is a principal crop in many mixed cropping systems, providing not only food but serving as an important nitrogen-fixing cultivar. Cowpea production has been hindered by serious disease and insect problems, and research is encouraged to resolve these problems as well as to investigate the crop's value in mixed-cropping systems.

* Because of recurring drought in Senegal, efforts should be made to identify drought-resistant, short-duration varieties of millet, sorghum, and corn. Focus should be on varieties already used by local farmers as well as those developed by plant breeders in Senegal and elsewhere in the Sahel.

g. Information sources

See Contact and Reference Nos. 2, 4, 10, 11, 18, 20, 22, 29, 34, 41, 57, and 59 listed in Section III.E.

2. Increasing soil fertility

a. Problem addressed

Senegalese soils are low to extremely low in natural fertility, which is aggravated in many areas by erosion and limited recycling of manure or crop residues. Low soil fertility is so serious and widespread that, next to low rainfall, it probably represents the major obstacle to increasing crop production in Senegal.

Current fertilizer formulations and recommended dosages for each crop are based on a "best guess" unrelated to local soil composition, crop history, or climate.

The Government of Senegal (GOS) subsidized fertilizer prices until recently, which led to some farmer misuse and/or failure to appreciate the real economic value of fertilizers.

Timing of applications, hence availability of fertilizers to farmers at the proper time during the cropping season, is critical to maximizing crop response.

Local farmers are aware that applying fertilizers can increase crop yields. Without exception, farmers said they wish to purchase and apply more fertilizer. However, both farmers and extension agents have only limited knowledge of the need to select and apply fertilizers based upon the specific nutrient requirements of individual crops, cropping history and patterns, soils, and climates.

Farmers appear unaware of different fertilizer placement techniques and their applicability for different crops and soil cultivation practices. Also, although they know that erosion reduces soil fertility, farmers do not understand the value of crop residues to the soil.

b. Description and source

Increasing soil fertility requires application of proper amounts of appropriately formulated fertilizers at the correct time within the crop cycle. Tillage practices and management of crop residues also are important aspects of the technology.

For example, large-stature cereals, including corn, millet, and sorghum, are often successfully grown in widely-spaced hills. If the hills were permanently maintained, fertilizer application could be easily limited to them. Furthermore, if such sites were catchment basins rather than hills, the basins would concentrate both nutrients and water near the growing plants. This concept could be immediately tested in on-farm trials, because both catchment tillage and hilling are already practiced in Senegal.

Increasing soil fertility requires a complex array of crop management inputs and practices. Sources of technologies and testing include international, national, and local agricultural research centers. Present farmer practices in some areas of the country may also be a source of technology and testing.

c. Stage of readiness for diffusion to farmers

Stages of readiness for the several components of this technology are summarized in Table 2 below.

Table 2

Stages of readiness for diffusion to farmers of technologies for increasing soil fertility. (Senegal)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
1) Hill or row placement	X		
2) Customized formulation			X
3) Split application (for rice)		X	
4) Incorporating crop residue		X	

Opportunities for yield increases through increasing soil fertility exist for virtually all ecological zones and farmers of Senegal. Fertilizer type, application method, quantity, and management will vary among ecological and socioeconomic zones.

d. Potential benefits and negative consequences

Increasing soil fertility would substantially increase cereal yields, farmer income, and food security in Senegal. Introduction and support of soil management technologies might also encourage crop and agricultural product diversification.

The negative consequences of introducing technologies to increase soil fertility would be minimized by proper adaptive research; introduction of technologies; extension worker and farmer training; and proper choice, timing, and application of fertilizers. If improperly used, environmental pollution could occur.

e. Constraints to increased farmer adoption

Agricultural:

* Complete adoption in Senegal of all possible technologies to

increase soil fertility is unlikely to occur because the agricultural support system is underdeveloped, and foundations have not yet been established to support the more sophisticated technologies.

For example, efficient fertilizer formulation and dosage recommendations must be based on field trials that consider soil composition, climate, and crop history. Based on results of field trials, application must be based upon accurate soil sampling and testing.

Senegalese soils have not been systematically mapped with enough precision to allow a soil composition input into fertilizer formulation. Farmers have inadequate access to soil laboratories in Senegal. Detailed soil surveys and field trials could require 20 years to complete, even if money and trained personnel were available.

Institutional:

* Almost every person (at every agricultural level) with whom the CTTA team spoke said the New Agricultural Policy (NAP), which stopped fertilizer subsidies and limited or eliminated credit, would severely limit fertilizer use by small farmers.

* Farmers said the fertilizer delivery system often failed to make fertilizers available when they were needed for crops.

* Introduction and support of practices to increase soil fertility will require a substantial, continuous system of training and information. The Senegalese extension system presently is unprepared to fill the gap between the existing knowledge of farmers and the knowledge they will need if they are to adopt many of the new technologies.

Socioeconomic:

* Technologies for increasing soil fertility that require cash inputs compete for cash directly with items that must be purchased for domestic use (including social and ceremonial obligations) and with other agricultural inputs such as seed. Although Senegalese farmers are aware that applying fertilizer can increase crop yields, they presently place low priority on adopting practices to maintain or increase soil fertility.

* National fertilizer economics -- the real cost of fertilizer versus farmers' ability to receive an adequate return to justify fertilizer purchase and application -- is a substantial economic constraint to widespread adoption of purchased input-based soil fertility practices. Fertilizer economics depend upon complex national policies covering cereal imports and purchases, pricing and subsidy issues, etc.

* Although returning crop residues to the soil reduces erosion

and improves fertility, residues are often used for feed, fuel, or building materials. It will be difficult to persuade a farmer to bury a valuable, harvestable product.

f. Issues for further consideration

* Split fertilizer application (critical when planting crops in warm, sandy, moist soils) is unknown to most farmers. Split application recommendations are available for rice, but not other cereals.

* Several scientists with whom the team visited (plus some reports reviewed by the team) suggested that row placement of fertilizer should be easy to introduce and implement in Senegal.

* Row placement of locally-available rock phosphate was repeatedly offered as a relatively easy solution to P deficiencies that characterize several Senegalese soils.

* Effective row placement at a more sophisticated level, especially of P, which is completely immobile in soil, would normally require mechanical planters. For economic reasons, it is unlikely that Senegalese farmers will soon convert to mechanical planters.

* State-of-the-art fertilizer dosages and formulations are based on technology presently unavailable in Senegal. Efforts should be initiated immediately to correct the present single, nationwide "best-guess" recommendation used for each crop.

* Existing soil surveys should be used to describe the fertility of Senegal's major soil groups, following which fertilizer response trials should be conducted for each soil group. This would facilitate limited custom formulation and dosage recommendations for major soils and regions.

g. Information sources

See Contact and Reference Nos. 2, 4, 11, 16, 17, 18, 20, 21, 22, 24, 28, 34, and 56 listed in Section III.E.

3. Improving soil management and tillage

a. Problem addressed

Shallow tillage methods currently used by Senegalese farmers limit cereal yields primarily by increasing the detrimental effects of drought. Shallow tillage does little to alleviate soil compaction, thus limiting soil aeration and root growth. Rain water cannot penetrate compacted soil, which encourages sheet erosion and poor soil water uptake and retention.

Erosion is considered a serious problem by most farmers; but poor aeration, water uptake and water retention problems are not well-recognized.

b. Description and source

Catchment and/or contour tillage, construction of bunds or erosion barriers, and practicing deep instead of shallow tillage could increase soil moisture retention, improve crop growth, increase yields, and reduce erosion.

Farmers are aware that excessive runoff and erosion are decreasing their crop yields and reducing their earning capacity. This could be used as a powerful motive for farmer adoption of soil and water conservation practices.

Research trials in Senegal provide the source of this technology.

c. Stage of readiness for diffusion to farmers

Stages of readiness for the several components of this technology are summarized in Table 3.

Opportunities for production increases through improved soil management exist for virtually all ecological zones and farmers in Senegal.

d. Potential benefits and negative consequences

Research trials in Senegal have demonstrated that deep plowing can increase corn yields by 52 percent over those with shallow tillage.

On the negative side, unless deep tillage of the type that buries crop residues is limited to fields with minimum slope, areas that were subject to sheet erosion under shallow tillage could be subject to severe erosion under deep tillage.

Table 3

Stages of readiness for diffusion to farmers of technologies for improving soil management and tillage. (Senegal)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
1) Shallow tillage	X	X*	
2) Deep tillage			X
3) Contour tillage/planting	X		
4) Catchment tillage	X		
5) Bunding/erosion barriers	X		
6) Vegetative barriers	X		

* Depending upon availability of equipment and draft power.

e. Constraints to increased farmer adoption

Agricultural:

* Little further research is needed to establish the benefit of deep tillage, contour tillage, catchment tillage, and erosion barriers.

Institutional:

* Substantial extension worker and farmer knowledge is necessary for satisfactory adoption and use of improved soil management and tillage. At present, the extension service cannot provide appropriate information or support to assist farmers in using the technologies.

* The extensive supply and maintenance infrastructure (trained blacksmiths, mechanics, veterinarians, etc.) necessary for widespread deep tillage adoption does not presently exist.

Socioeconomic:

* The cost of implements and draft power (animals and machines), will prevent small farmers from adopting the more intensive aspects of the technology.

f. Issues for further consideration

* Some Senegalese farmers have begun to implement practices to improve soil water retention and reduce erosion. These include digging depressions around sorghum plants during the first weeding to collect rain water, and building bunds or barriers to slow or block runoff water. The team saw examples of two such barriers. One consisted of a row of stones that interrupted water flow and trapped eroding soil. Another consisted of rows of pruned trees or hedges that established a deep-rooted vegetative barrier to runoff. These vegetative barriers might also be used as crop shelters, and as a source of organic nitrogen (see Section III.B.6, Technology-Related Observations and Recommendations).

* Parts of fields immediately uphill from water and soil movement barriers will become relatively more productive than areas just below. These more productive sites would be excellent candidate locations for row-placed fertilizers (see Sections III.B.2 and III.B.3, Increasing Soil Fertility and Improving Soil Management and Tillage).

* Deep tillage is often thought to mean moldboard or "clean" plowing. Moldboard plowing is rapidly being replaced by conservation tillage methods that penetrate the soil as deeply, but leave 50-80 percent of crop residues on the soil surface. Conservation tillage deters wind and water erosion, and normally requires much less energy and time than clean tillage. Conservation rather than clean tillage should be researched in Senegal.

g. Information sources

See Contact and Reference Nos. 2, 4, 16, 17, 20, 21, 22, and 34 listed in Section III.E.

4. Optimizing seed placement and row spacing

a. Problem addressed

Crops are not planted in rows in many Senegalese fields. In others, row spacing is erratic and asymmetrical, making weeding, cultivation, and other field operations difficult.

Farmers are generally unaware of the benefits of optimal plant spacing. Fertilizers are broadcast, which is inefficient and encourages weed growth.

b. Description and source

The technology consists of planting crops in rows with optimal between- and within-row plant spacing. Row planting facilitates soil cultivation and fertilizer application. Inter-row zones should be rough, strewn with litter, and unfertilized. Such zones increase water uptake, reduce erosion, and discourage weeds (see Section III.B.5, Improving Pest Control).

Research and planting trials conducted in Senegal (by ISRA) and other countries confirm the benefits of row planting.

c. Stage of readiness for diffusion to farmers

Stages of readiness for two practices related to this technology are summarized in Table 4 below.

Table 4

Stages of readiness for diffusion to farmers of technologies for optimizing seed placement and row spacing. (Senegal)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
1) Orderly rows via hand or small draft labor	X		
2) Use of mechanical planters with fertilizer applicators			X

Opportunities for production increases through optimizing seed placement and row spacing exist for virtually all ecological zones, farmers, and crops in Senegal.

d. Potential benefits and negative consequences

Row planting, accompanied by improved plant spacing and increased fertilizer application should be tried and encouraged in Senegal. Adopting such practices would increase productivity of farming operations; facilitate row-placement of fertilizers, hence increase fertilizer efficiency; and reduce erosion (see Section III.B.3, Improving Soil Management and Tillage). Researchers in Senegal should continue to test and adapt minimum tillage techniques that have been developed and adopted in other countries.

e. Constraints to increased farmer adoption

Agricultural:

* In its simplest form (hand-labor level), there are few agricultural constraints to introducing row planting. Constraints increase with more developed forms which require plows, mechanical planters and fertilizer applicators, and herbicide application. Although simple forms of row planting could be immediately implemented, research and on-farm trials will be needed to determine which variations of the concept are most suited for agricultural conditions in Senegal.

Institutional:

* Information for farmers about row planting, between- and within-row plant spacing, and optimum plant population is limited. The research-extension-communication system must be strengthened.

Socioeconomic:

* Row planting at even intervals, even in its simplest form, requires more labor than random planting, as does point-placing versus broadcasting fertilizer. More complex forms have the additional economic constraints of requiring purchased draft power and machinery.

f. Issues for further consideration

Issues for further consideration are included in the foregoing section.

g. Information sources

See Contact and Reference Nos. 2, 4, 11, 16, and 22 listed in Section III.E.

5. Improving pest control

a. Problem addressed

Weeds, diseases, insects and birds limit production per unit area in Senegal. Of these, weeds appear to be the major problem. These problems are widely recognized by farmers.

b. Description and source

This set of technologies consists of implementing improved or modern methods of controlling important crop pests such as weeds, diseases, insects, and birds. The specific technologies for each pest are listed in the section which follows.

Improved pest control requires a complex array of crop management inputs and practices. Sources of technologies and testing include international, national, and local agricultural research centers. Present farmer practices in some areas of the country may also be a source of technology and testing.

c. Stage of readiness for diffusion to farmers

Weeds. Two important aspects for improving weed control are ready for diffusion and at least two others are promising, as indicated in Table 5.

Diseases. Problems with plant pathogens can best be dealt with by the development of resistant varieties. Local and international plant breeders are placing emphasis on this effort. This technology qualifies for all three levels of readiness as some improved varieties are now available, and others will be in both the near and more distant future.

Insects. Plant breeders at international centers are investigating integrated approaches for reducing crop losses from insects, an almost ready technology.

Sealed drums to store cowpeas, with no insecticide application, were used in 1986/87 season on-farm storage experiments. The damage by cowpea weevil was quantified five months after storage. Less than 9 percent damage, acceptable in international markets, was found in 55 percent of the 76 experiments. In 89 percent of the experiments, damage was less than 16 percent, acceptable for local markets. Drum storage failed in a small number of cases, and research should be continued to determine the cause. This technology appears to be effective, however, and is being adopted.

Birds. One researcher (22) stressed the need to select and introduce maize varieties with long, light husks to minimize bird damage. Farmers now break over the stalks to remove the birds' perch. Brown-seeded sorghum with high tannin content is not attractive to the

tiny birds that descend by the hundreds of thousands and can demolish fields of pearly white sorghum. Brown-seeded sorghum is being grown increasingly as a result, although people often dislike its slightly bitter flavor.

Stages of readiness for technologies related to these four types of plant pests are summarized in Table 5.

d. Potential benefits and negative consequences

Potential benefits are identified in the foregoing section.

The use of chemical pest controls carries with it attending needs for safety and safeguards for preventing danger to users or the environment.

e. Constraints to increased farmer adoption

Agricultural:

* Few, if any, agricultural constraints exist for aspects of the technology that have been developed.

Institutional:

* The farmer's knowledge level and management ability in using pest control measures appear to be an institutional constraint. He must have someone knowledgeable to turn to for that information and assistance, such as an extension agent or other person with ready information.

* Pesticide applicators typically are not available where and when farmers need to use them, and farmers need to be trained in the safe and accurate use of that equipment.

Socioeconomic:

* Social factors such as resistance to new methods of pest control, and changes in row planting as opposed to traditional methods, can pose a barrier to adoption. Economic constraints include lack of money to buy chemicals and equipment for the more sophisticated aspects of the technology.

f. Issues for further consideration

* Harvest and storage procedures need to be evaluated. Current procedures often result in considerable losses due to the development of a variety of molds and fungi on the grain. Sometimes, crops mature before the rainy season ends. The grain, which is left standing on dead stalks in the field, is invaded by fungi. In many cases, grain is harvested and stored before it is properly dried (at moisture levels of 25 rather than 12 percent, for example).

Table 5

Summary of technologies for improving pest control and their stages of readiness for diffusion. (Senegal)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
1) Weeds:			
Improving timeliness of weeding	X		
Establishing straight rows or growing zones to facilitate weeding and allow fertilization of crop rather than weeds	X		
Improved mechanical weeders			X
Use of herbicides			X
2) Diseases:			
Problems with plant pathogens can best be dealt with by the development of resistant varieties.	X	X	X
3) Insects:			
Integrated approaches for reducing crop losses from insects		X	
Sealed drums for cowpea storage, with no insecticide application.		X	
4) Birds:			
Brown-seeded sorghum, not attractive to birds, being grown increasingly.	X		
Maize types with long, light husk leaves will prevent or discourage birds from consuming the grain as it stands in the field.			X
Current farmer practice, walking their fields and bending the corn stalks over below the ear, thus removing the perch for feeding birds.	X		

Technologies for improving pest control are appropriate for all ecological zones and farmers in Senegal.

The architecture of the storage is such (round granaries of woven branches approximately 2-3 meters in diameter and 2 meters high placed directly on the ground) that aeration and drying are very difficult. It is recommended that storage structures be modified to approximate U.S. midwest corn cribs (about 0.5 meters wide, 2 meters high, any length, elevated about 0.5 meters above the ground, and covered with a sloped thatch).

* Neem leaves and leaf extracts have traditionally been used in Senegal as effective stored grain insecticides. This indigenous technology does not seem to have been adequately scientifically investigated in Senegal, but would appear to have important potential. In the meantime, the team concludes that efforts should be made to extend its indigenous use.

g. Information sources

See Contact and Reference Nos. 2, 11, 18, 22, 34, and 41 listed in Section III.E.

6. Technology-related observations and recommendations

Five additional technological areas were identified that show considerable promise for increasing cereal production in Senegal, although additional research is needed to determine their full potentials. All are related to the major technology sets just discussed. Although time constraints precluded the possibility of examining these areas in depth, each is discussed briefly below, and some recommendations are offered.

a. Improving timeliness of operations

Both researchers and farmers commented that crop yields are frequently limited by failure -- or inability -- to perform farming operations on time. Farmer concerns centered on unpredictability of rainfall and late delivery of fertilizer and seed. The erratic rainfall issue is addressed in the next section, response farming. It appears clear that major improvements in the present unreliable delivery system will not come easily.

Although late and/or unreliable seed and fertilizer delivery surfaced as often as any other single farmer frustration, it should be noted that the majority of Senegal's dryland cereal farmers use their own seed and are not yet aware of the existence of chemical fertilizers. Therefore, programs to increase farmer awareness of, knowledge about, and interest in using improved seed and fertilizer must be synchronized with institutional improvements to make these inputs available to farmers as and when needed.

A well-designed and implemented communication effort could lead to significant improvement/development in at least two aspects of timeliness of operations that appeared to affect virtually all Senegalese farmers.

The first might be termed "time intensification" to increase productivity per unit of arable land. Senegal's land suitable for cropping is limited -- and dwindling; and its human population is increasing. It is therefore urgent that the nation find ways to intensify crop production on its present hectarage.

Senegal has a cropping season of about four months, with fields remaining dry and fallow during the remaining months. As much as possible, the off-season should be used to build erosion barriers, dig catchment basins, align contours, and make other land improvements (see Section III.B.3, Improving Soil Management and Tillage) -- as well as to prepare for the next cropping season -- so that planting, weeding, etc., will not be delayed because of competing jobs that could have been performed during less critical times. The resulting "time intensification" could make a great difference in productivity per unit of arable land.

It is recommended that the "time intensification" concept be evalu-

ated, taking into consideration the annual migration of men from farm to city for off-season employment. Such migration obviously limits the labor available for off-season tasks, and farmers may not return to their farms in time for timely planting or weeding. This situation is likely to continue until farmers can earn a more stable and satisfying income from their land.

Second, it was observed that many Senegalese farmers (like farmers around the world) do not appear to fully appreciate the productivity and/or economic value of timely weeding. Weeding operations, which often consume the majority of a farmer's within-season efforts and time, are affected by rainfall patterns -- including erratic onset and unpredictable duration -- accepted by farmers as being beyond their control. They should not assume, however, that timely weeding is also beyond their control. On the contrary, once planting and primary tillage operations are complete, weed germination and growth can be accurately observed and monitored.

If fields are weeded shortly after a rain when weed seedlings are small, labor is easy and effective; and weeds are removed before serious competition with the crop for moisture and nutrients occurs. If weeding is late, weeds are large and deeply-rooted, and may have set seeds; labor requirements are greatly increased, and crop yields are often reduced by competition for water and nutrients.

United States farmers are being encouraged to become less dependent on chemicals through improving their mechanical weed control. They are being instructed to cultivate their weeds in the "barely see them" stage. Senegalese farmers should be similarly encouraged to focus their weeding efforts on the "barely see them" stage, even to the extent of having family members abandon other domestic duties during the three or four days when weeding is easiest and most effective. Such efforts could reduce season-long labor by orders of magnitude, plus have a substantial effect on yield. As indicated in Table 5, this concept is ready for diffusion.

b. Response farming

Before departing the United States, the team was made aware of a relatively new agroclimatological concept, "response farming," based on research done in Kenya, Morocco, Cyprus, Jordan, and Nepal. Response farming employs newly-developed rainfall analysis to predict a narrowed range of possible rainfall amounts and rainy period durations in the approaching or just beginning rainy season.

In Niger, a similar concept -- called "weather responsive crop management" by ICRISAT staff -- is arousing interest. (See Section IV.B.6.)

If the average date for onset of rains in his location and the association between that date and length of the growing season were

known, a farmer could observe the date that rains commence and adjust his cropping decisions (primarily season-length of cultivar) accordingly. (The date of rain commencement is defined as the earliest day after 1 May when rainfall accumulated over three consecutive days is at least 20 mm.) The result would be to minimize the effects of drought by making the most efficient use of scarce rainfall in a drought year, but maximizing production in good years by exploiting the longer growing season.

Based on the promotion being given to these related concepts internationally, and supported by the references cited below, the team recommends that response farming be considered an idea with promise for Senegal.

- Researchers in Kenya (59) found the total crop failures with corn could be reduced from the conventional one season in two to one season in seven with medium level management (i.e. without using commercial fertilizers or other costly inputs) and to one failed season in nine with high level management inputs.

- In the Miles Report (50) it was reported that by going over the annual precipitation records for the Sahel (past 134 years) one can calculate probability of wet or dry years for the coming year or two. For example: in 1985, one would have concluded that there was a "very strong chance that the years 1986 and 1987 would be wet, without excluding the possibility that the wet period could be much longer (5, 10, or 15 years) . . .the probability that the year 1985 would be followed by at least two other wet years was 92 percent."

Ability of the system to respond to a change in plans (switching from one crop to another on two weeks notice, for example) is unlikely.

Potential constraints include unavailability of rainfall data, which may be overcome by regional correlation studies and interpolation and research; and inadequate infrastructure or supply systems to handle inputs with demand possibly changing radically in short time periods.

Information sources: (2, 9, 8, 11, 16, 18, 21, 22, and 59)

c. Introducing new crops

Corn. Agricultural scientists in Senegal, and across the Sahel, agree that increasing corn production is important to achieving regional self-sufficiency in cereals. Special efforts are needed to promote and improve corn, a crop that currently occupies only two percent of the cultivated hectarage in Senegal.

Although flint types of corn appear most popular among villagers

because they mill nicely for couscous, most corn variety improvement efforts in Senegal (and worldwide) focus on dent types. The latter are not presently well-received by Senegalese farmers because of their different milling properties. This suggests that: 1) flint corn be given special emphasis in Senegal's local corn improvement program; and 2) the many dent corn preparations popular worldwide be promoted in Senegal.

All forms of corn (flint, dent, floury, white, sweet, and pop) should be promoted in Senegal. For example, green corn (corn harvested before complete maturity and roasted over charcoal), which has been introduced into the country, is popular and commands an excellent price in both rural and urban markets. It should be promoted as an excellent cash crop.

Cowpea, like corn, currently occupies only 2 percent of Senegal's cultivated hectarage. During the severe drought of the 70s, when sorghum and millet produced no grain in some areas, cowpea produced useful quantities of seed for food -- it has been called a "crop of security." Unfortunately, cowpea has serious insect and disease problems that must be resolved through research; such research is encouraged.

Sesame, a drought-tolerant, high-value, oilseed crop that reportedly produces well on sandy soils which receive 250-300 mm rainfall, is produced in other Sahelian countries and appears to be well-suited for introduction into Senegal. Agricultural constraints appear minimal, as the crop does well under ecological conditions similar to those in Senegal (e.g., in Cameroon, Morocco, and Sudan). The most serious constraints to widespread farmer adoption appear to be lack of existing internal demand or markets.

Time did not permit investigation of the gamut of world crops that might be successfully grown in Senegal. Considering the country's need to overcome its overdependence on peanuts, special efforts to diversify its crops are strong encouraged.

Assuming that institutional constraints such as the above-mentioned internal demand and market constraints for sesame are alleviated, successful introduction of a new crop with which farmers are not familiar is still typically contingent upon a comprehensive technology transfer strategy and program that effectively provides the farmers with relevant, timely information about producing, harvesting, processing, and marketing the crop (including where and how to obtain seed and other needed inputs, etc.), and feedback from the field to input and service providers, policy makers, research, extension, and others. It is recommended that such strategies and programs be given high priority and integrated into all crop introduction and diversification programs.

Information sources: (2, 4, 9, 21, 22, 34, and 41)

d. Alley cropping

In an alley cropping system, food crops are grown in alleys formed between hedgerows of fast-growing trees or shrubs. The hedgerows serve as windbreaks that not only reduce erosion but also establish favorable microclimates for crops. Many of the best hedgerow species are nitrogen fixers; and hedgerow prunings can be used as mulch for companion food crops, as fodder for livestock, and as firewood, stakes, and building poles.

Possible negative consequences of alley cropping would be competition from tree/shrub crops reducing the yield of food crops, and the provision of habitats for birds, insects, and diseases. Research in Nigeria and Rwanda has shown, however, that Leucaena prunings provided 40 kg N/ha for corn, did not compete adversely with corn, and that scattered Leucaena seeds did not increase weeding requirements.

Alley cropping is a complex system. Constraints to adoption include availability of seeds; high management requirements; and knowledge necessary for appropriate tree selection, planting, crop combinations, crop selection, pruning, and harvesting. Communication of this information requires a well-informed and supported extension service. The team considers alley cropping to be promising for Senegal.

Information sources: (11, 16, 22, 34, 41, and 59)

e. Exploiting the rotation effect

The benefits of crop rotation have been known for centuries and are well documented. Rotation as a management practice has recently received increased international attention due to the discovery that:

- rotation benefits persist even beyond optimal levels of all aspects of management (including nitrogen and other nutrients, water, pest control, and soil physical properties);
- the rotation benefit appears to increase proportionally with stress or where crop yields are routinely low; and
- in many developing areas farmers do not follow proven or tested rotation patterns.

It was observed that most Senegalese researchers consider the benefits of rotation to be due primarily to the nitrogen introduced into a rotation sequence by including a nitrogen-fixing legume. It is also commonly accepted that pest problems can be reduced by rotation. The team wishes to emphasize the research-proven observation that crop rotations provide a yield benefit in addition to, or in the absence of, a nitrogen contribution or pest problem

(weeds, insects, diseases).

Sorghum will yield better if rotated with corn or millet and vice versa -- a fact that is not well known -- even though these three crops are very similar in growth habit and physiology. Nitrogen-fixing legumes (such as peanut) benefit from being rotated with another crop. In fact, although it is likewise not well known, any or all crops apparently benefit from rotation regardless of the alternate crop(s).

Promotion of crop rotations in Senegal whenever possible is strongly encouraged. Numerous international research trials confirm that grain yields can routinely be improved by 15 percent or more (especially in low yielding ecologies such as those that characterize much of Senegal) simply by alternating, rather than continuously producing, crops.

There are no serious agricultural constraints to implementing rotations, since nothing new or different is required of the farmer. Simply stated, he must not plant any one plot of ground to the same crop year after year. The farmer cannot maintain a perfect rotational pattern, however, unless there is strong demand or market for two or more crops. For example, if a farmer, because of his situation, found it preferable to plant 2/3 of his land to peanuts and 1/3 to millet every year, he could not avoid planting some of his land to peanuts at least two years in a row.

Pricing policy, especially for peanuts, plays an overriding role in Senegalese crop rotations. Few other socioeconomic constraints would appear to be significant in improving rotational practices, however. In many cases, the practice is ready to be promoted.

Information sources: (2, 4, 11, 16, and 21)

C. Linkages of Research with Technology Transfer Institutions

UNIVAL, the Information and Valorization Unit of the Senegalese Agricultural Research Institute, has potential for establishing communication linkages with technology transfer institutions responsible for working directly with farmers (regional development authorities, PVOs, NGOs, etc.). Little evidence was found that such linkages presently exist, however.

The consensus among researchers interviewed was that they do their own extension work as time permits (22, 10, 16, 19, 14, 15). However, some said extension personnel and researchers must be involved in teaching farmers about the technology if technology adoption is to occur (22,19).

A SODEVA representative at Kaolack (20) said the 21 agents he supervises lack formal contact or information from researchers. The agents receive no information, training or updating on new developments. If an agent has a question, he must resolve it interpersonally. The representative was not familiar with UNIVAL.

The new USAID Agricultural Support Project (APS) may provide a communication linkage. The project proposes to facilitate privatization of agricultural input distribution and cereal seed multiplication (57). In addition to the outputs of input supply and seed privatization, input supplier credit expansion, and agricultural statistics collection, the project will finance an educational mass media program to explain the benefits of using better seeds, cost effective fertilizers, appropriate equipment, and crop protection products.

Many NGOs and PVOs are working in Senegal, and there is evidence of some research-NGO linkages. For example, one NGO is providing a nursery for trees to use in alley cropping (10). With the exception of such occasional linkages, there appear to be no specific linkages established to communicate agricultural information to NGOs and PVOs.

D. Diffusion of Technology to Farmers

In addition to identifying and categorizing agricultural technologies in the collaborating countries, the study team's scope of work also included providing recommendations for improving diffusion of ready and almost ready technologies. Important constraints to information flow were identified that apply to the communication of all agricultural technologies in Senegal.

1. Technology transfer system

Senegal has done a commendable job of institutionalizing innovation development by creation of a research organization, ISRA. It is now time to take the next step -- to develop and strengthen a viable

and dynamic technology transfer system that uses communication strategies and methods effectively in combination with conventional extension methods to diffuse innovations generated by the research system to farmers. It is critical that the system include mechanisms that establish and maintain effective linkages and two-way information flow among farmers, researchers, extensionists, and others involved in technology transfer.

One of the most critical present constraints to diffusion of identified technologies to farmers is lack of an effective extension capacity. Senegal presently has neither a cohesive national extension program nor built-in extension/research links whereby extension agents can be updated on new research. The responsibility for transferring technology is divided among several entities that typically function with minimal coordination and collaboration. The example cited earlier from SODEVA, a regional development authority with extension responsibilities, illustrates the situation well.

Under the present NAP plan to eliminate regional agricultural authorities, the need to develop a national extension program that reaches farmers effectively and regularly (and that provides systematic, dependable feedback from the field to researchers, policy makers, etc.) will become even more urgent. This extension program must be more than information dissemination and feedback, however, important as both are. It must also be educational, as management skills and application are critical to successful adoption and use of all of the technologies identified in Section III.B.

An early need is to develop a systematic process for determining when a given technology is ready for diffusion to farmers. The most critical element in such a system is information flow: at all stages in the technology's developing, testing and adaptation; between and among researchers, farmers, extensionists, input and service providers, and policy makers; presented in a form and in language understandable to the intended users; and, continuing updated information and training to extension that can in turn be used in working with farmers.

Recommendations for improving diffusion of improved technologies must include more than mass media. Communication by mass media can create awareness (several sources reported to the team that farmers are already aware of new technologies), arouse interest, and, under some circumstances, lead to adoption of relatively simple improved practices/technologies. However, the extensionist is still needed for the educational role to work directly with farmers, especially on management-related skills and their application. Both media and extensionists are needed, as well as the types of information flow emphasized above.

Several important constraints to information flow were identified that could serve as points of intervention, or opportunities, to strengthen Senegal's present technology transfer system.

2. Recommendations for improving diffusion

Information flow and, consequently, diffusion would be strengthened by establishing the following specific communication linkages:

1) UNIVAL (Unite d'Information et de Valorization) could become an important communication link. The unit has access to researchers, receives reports of all research, and has responsibility for increasing the value of this information to the users -- including other scientists or extension agents. It has access to, and could develop greater capability in use of, mass media. ISRA researchers said they look to UNIVAL to perform a dissemination function.

   Maintaining a repository of documents and circulation of documents within the system can be beneficial to the research efforts. At the point of valorization, a communication linkage between UNIVAL and agencies with extension responsibility could aid the interchange and information flow between research and extension.

   UNIVAL is not presently regarded by extension agencies as a source of information. Thus, there is opportunity to increase its visibility as an information source for extensionists and, perhaps, PVOs and NGOs.

   Consideration should be given to strengthening UNIVAL's role in increasing the accessibility of research information to extension workers and farmers. Further study of the specific opportunities will be required to develop an appropriate organizational and communication strategy for this purpose.

2) The USAID Agricultural Production Support Project (APS) contains a large mass media component designed to increase farmer awareness and motivation in the use of credit for seeds, fertilizer, and equipment. Mass media can increase the farmers' awareness and knowledge of available alternatives; but media support needs to be reinforced through extension support system channels. Attention should be given to the broader role for communication in information flow, to include supporting of farmers with a base of management knowledge while the farmers' awareness of the technology is increasing through mass media.

   Linkages should be established between the APS project and UNIVAL to ensure that information used in mass media is indeed supported by facts and built upon information generated during the GOS agricultural research and demonstration activities, as stated in Annex I of the APS project paper.

3) Knowledge and skills farmers will need to adopt the "ready" and "almost ready" technologies identified in Section III.B should be determined, and used as the basis for developing information modules for extension agents and farmers; and training modules to teach management skills associated with each technology.

4) Although training personnel could not be contacted, it appears that at least two organizations outside ISRA could provide training to extension agencies: The Crop Protection Service and the Dakar Training Center. Within ISRA, the Unite de Programmation et de Formation could also provide some training. There are opportunities to strengthen information flow by establishing linkages between UNIVAL and these units, by strengthening communication support to training, and by establishing interfaces between research and extension.

5) NGOs and PVOs, which work directly with farmers, cannot take the place of a cohesive national extension effort. Nevertheless, communication support from, and linkages with, UNIVAL could provide an important supplemental flow of technology information to farmers. Such possibilities should be investigated.

6) UNIVAL badly needs trained agricultural communicators. Given the emphasis that will be placed on agricultural communication in Senegal, more trained agricultural communicators will be needed to work in mass media and to prepare training materials. Consideration should be given to training agricultural communicators to meet Senegal's future needs.

E. Contacts and References

1. CTTA Team contacts

USAID (United States Agency for International Development)

1. Wayne R. Nilsestuen, Chief, Agricultural Development Office
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CIRAD (Centre de Cooperation Internationale en Recherche Agronomique Pour le Developpement [France])

21. Guy Pocthier, Delegue

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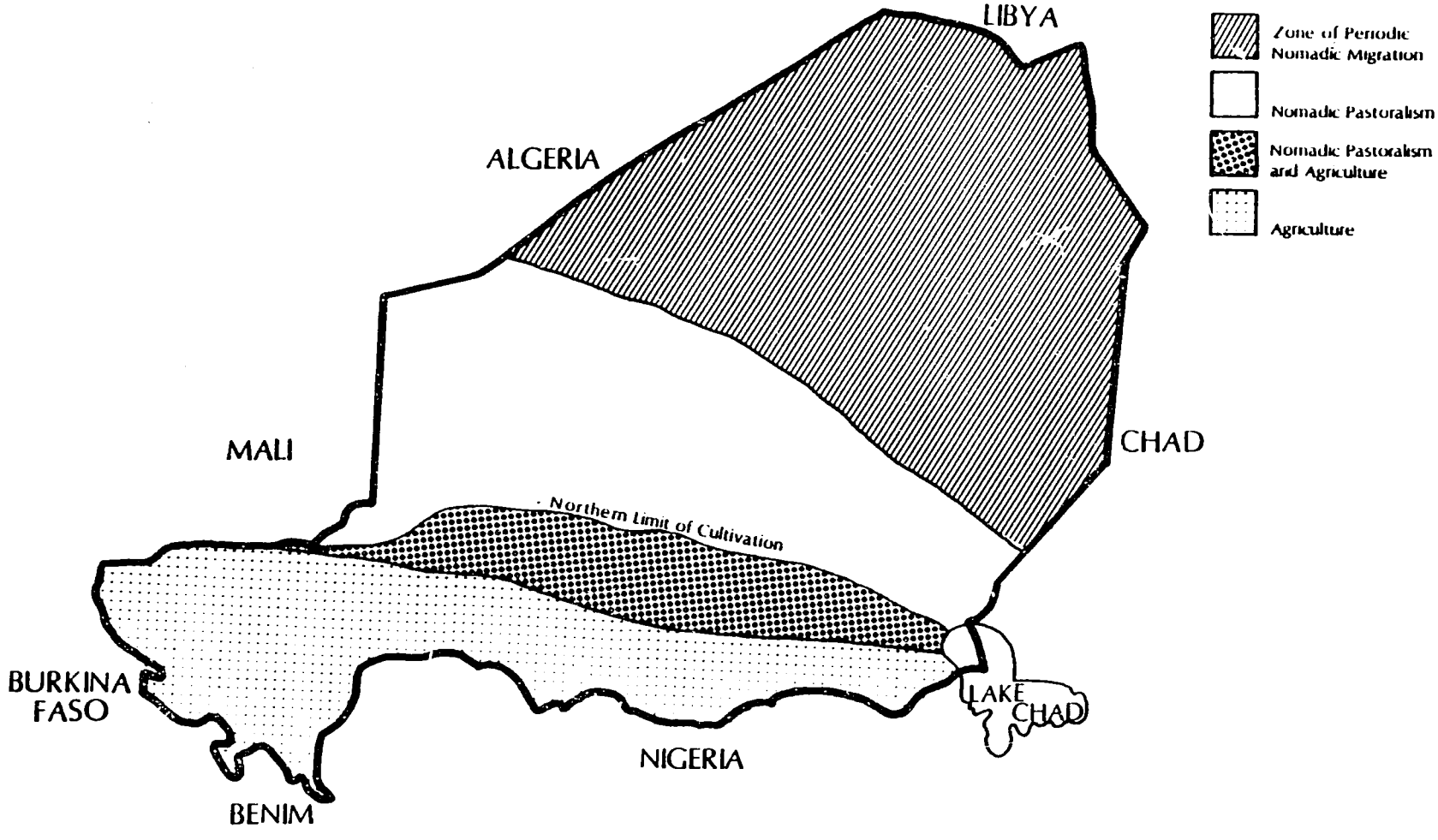
NIGER ECONOMIC ACTIVITY



IV. TECHNOLOGY IDENTIFICATION AND ASSESSMENT

NIGER

The technology identification and assessment investigation for Niger, limited primarily to rainfed cereals, was conducted in-country during the period 15-26 November 1987. Results of the study, organized into eight major technology sets, are presented below.

A. Background

USAID/Niger confirmed its interest in collaborating in the Assessment described in Section I, agreed to the proposed terms of reference, and determined dates for the in-country investigation, through telephone conversations of 9/15-16/87 and telexes of 10-11/87. Upon the team's arrival in Niger, the Mission requested that the team present the preliminary draft of its report to USAID, and indicated that they would communicate the results to INRAN (Institut National de Recherche Agricole du Niger) as necessary.

In addition to its interest in the stated purpose of the investigation, the Mission also expressed a number of concerns regarding the communication of technologies to farmers -- particularly in relation to what would become of the groundwork laid by the Agricultural Production Support (APS) Project scheduled for termination next year. The APS Project has given much effort to strengthening communication linkages between researchers and extension agents, and in developing extension agent training on their role in working with farmers and taking research recommendations to them.

A tentative schedule of visits was developed following initial meetings at the USAID Mission on 16 November, based on suggestions from Mission personnel. The Mission provided transportation and, within the telephone system's limitations, contacted each person to be interviewed.

The Nigerien research system, INRAN (Institut National de Recherche Agricole du Niger), is very conscious of protocol, and hierarchical in its communication organization. During their first meetings with the team, both Mission Staff and the ICRISAT/Niger Director stressed that contacts must be made at the higher levels of the system before any contacts are made at other levels (scientists working in the system, for instance). USAID/N was informed that initial contact with the INRAN Director General could not be arranged until Thursday or Friday of the team's first week in Niger, a meeting subsequently postponed until Monday, 23 November, severely limiting opportunity for team contacts with INRAN researchers.

Similarly, it was not possible to arrange interviews with Nigerien researchers through ICRISAT personnel.

Although the team early expressed a desire to talk to farmers, and it appeared that there would be opportunities to do so during scheduled field trips, these did not materialize. Farmers were not available in some cases and, in others, time constraints made it impossible to make contact.

From a research identification and assessment perspective, the lack of Nigerien scientist or farmer input into the report was a source of serious frustration to the team. However, the persons to whom the team had access were excellent sources of information.

The assessment and recommendations presented and discussed herein are based on

- study of reports and other documents;
- interviews with administrators and scientists at national and international levels;
- interviews with researchers working directly with villagers;
- observations from field trips to N'Dounga and the Guesselbodi forest management area;
- interaction with USAID staff and representatives of international research organizations; and
- experience of the consultants with agricultural research and technology transfer programs and with International Agricultural Research Center programs in Africa, Asia, and Latin America.

They represent the best judgment of the consultants based on information that could be obtained during the time and from the individuals available. Due to time constraints, much is impressionistic -- the report reflects and summarizes information and opinions received from those interviewed in a manner conducive to drawing conclusions and consensus as to technologies available and constraints to adoption.

The team's schedule in Niger is summarized in Appendix 3. Principal contacts made and documents reviewed are listed in Section IV.E.

B. Agricultural Technology Assessment

Assessment of the stage of readiness for diffusion to Nigerien farmers of new or underutilized technologies involves more than ecological and historical crop distribution factors. It also requires consideration of several other factors, any one of which may place an absolute or near absolute constraint on widespread farmer adoption. Among these should be cited local adaptation; infrastructural, institutional, and socioeconomic constraints; and government policies.

For example, the practicality of a given technology to farmers in a region (although it may have been tested on farms, and proven

to be locally adapted and potentially beneficial) depends, also, on farmer access to credit, inputs and markets. Input/price relationships affect its economic viability. And government policies may be either incentives or disincentives, depending on the policy.

As in Senegal, the team limited its Niger investigation to identification and assessment of technologies related to rainfed cereals. Insofar as time permitted, the identified technologies were separated into their individual components, each of which was then categorized as being "ready", "almost ready", or "promising" for diffusion to farmers (as defined in Section I.A).

The eight technology sets identified and studied by the team are described and discussed in the sections which follow.

1. Phosphate (P) fertilization

a. Problem addressed

Lack of adequate rainfall and its variability are most often considered to be the greatest limiting factors to crop production in Niger. However, most agronomists argued that -- although rainfall is certainly significant -- low soil fertility (specifically lack of phosphate) is even more limiting. They have repeatedly observed that phosphate fertilization could easily double cereal yields.

Although farmers who have seen phosphate response trials are convinced of its benefits, most farmers are not aware of the existence of inorganic fertilizer. Of those who do know about phosphate, use of P is their single most important input priority and they become frustrated if they cannot obtain credit to purchase it. Some farmers purchase fertilizer with cash, but usually apply less than the recommended dose.

b. Description and source

The technology consists of adding inorganic phosphate fertilizer to the soil.

Response to nitrogen (N) in Niger appears dependent upon the presence of phosphate. Crops do perform better if N and P are added in combination. Nitrogen is not recommended by ICRISAT, however, because it is expensive, losses from leaching and denitrification are high, and management is difficult (crops are often burned when a small amount of rain is followed by a dry spell). Potassium (K) is not recommended in Niger except for rice.

Intercropping with cowpeas is common in Niger, and could be another source of nitrogen that, in conjunction with phosphate, could effectively raise yields.

Fertilizer response trials conducted in Niger constitute the source of this technology.

c. Stage of readiness for diffusion to farmers

At the research level, phosphate fertilization has been demonstrated to have a significant effect on the yield of all cereals. Because of soil and rainfall variability, however, more on-farm testing to adjust dosages is needed before widespread diffusion is encouraged. As shown in Table 6, the stage of readiness was deemed 'promising' because of serious economic and institutional constraints.

All of the arable lands in Niger are low in phosphate.

Table 6

Stage of readiness for diffusion to farmers of phosphate fertilization technology. (Niger)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
Field application of partially acidulated rock phosphate			X

d. Potential benefits and negative consequences

Additions of P to Nigerien soils can easily double cereal yields. ICRISAT trials conducted cooperatively with INRAN in Niger provided the following results which illustrate the type of response typical of millet, sorghum and cowpea.

Treatment	Millet Yield
No Fertilizer	270 kg/ha
30 kg P/ha	800 kg/ha

ICRISAT scientists report as much as a 60 fold yield increase following P application in some farmers' fields.

On the negative side, repeated phosphate applications could result in micronutrient deficiencies over time because of large harvests being removed from Niger's sandy soils. Also, sulfur deficiencies will definitely develop unless a sulfur-bearing form of P fertilizer is used (see Issues Section below).

e. Constraints to increased farmer adoption

Institutional:

* One institutional constraint to phosphate fertilizer use at present appears to be inadequate supply. Although Niger has rock phosphate deposits, it lacks facilities to prepare the processed product. Phosphate fertilizer is presently brought in from Nigeria at subsidized prices.

* A second institutional constraint is the lack of available credit for buying fertilizer.

* Ancillary to the phosphate supply problem, the distribution network (warehouses, distribution centers, personnel and transportation) is an important constraint to widespread use of fertilizer, given the vastness of Niger.

* There is a dearth of trained extension agents to support the farmers' needs for management information on fertilizer use.

Socioeconomic:

* As with most inputs, the cost of phosphate fertilizer is frequently the greatest constraint to its widespread use among small farmers. Fertilizer was supplied at government-subsidized prices in the past and, even today, phosphate from Nigeria is supplied at less than real cost prices. This situation has made the farmer less conscious of the real cost of fertilizer.

* In many cases, farmers want only self-sufficiency in cereal production -- they do not benefit greatly from large surpluses, especially given normal market conditions. If cash markets were available for alternative crops, or forage crops, there would be incentive to use fertilizer if cash and credit were available.

f. Issues for further consideration

* Niger has at least two very rich phosphate deposits. Direct application of these raw crushed phosphates has been shown to double millet yields. But yields can easily be tripled if the crushed rock is treated with sulphuric acid before being applied. The treated product, known as partially acidulated rock phosphate, can be produced with only a fraction of the sulfuric acid used to produce water-soluble P fertilizers. This less expensive product is 85 percent as efficient as single super phosphate in terms of providing a field yield response, and thus could adequately meet the P needs of millet with the potential of saving substantial sums in foreign exchange for Niger. Investigation of changes or assistance to the infrastructure necessary to facilitate this technology could have important effects upon availability of P at reasonable cost.

* A crop response to added organic matter (crop residues) has been observed in Niger. The residues appear to alleviate aluminum toxicity which is a problem on many of the country's low pH soils. Examination of present conservation tillage practices in which organic matter might be added to soil could take advantage of this information.

* Fertilizer is presently applied in Niger by broadcasting. The idea of more efficient (row or hill) placement is being considered by researchers, and may become a part of their recommendations. The concept of permanent hills (which would be the only field sites to receive P applications, thus maximizing efficiency) is not feasible because blowing abrasive sands remove all traces of a previous year's hills by the time of the next planting. However, row or hill placement each year is still cheaper and more efficient than broadcast applications and should be investigated as an alternative to broadcasting.

q. Information sources

See Contact and Reference Nos. 2, 3, 8, 9, 10, 13, 15, 16, 17, 18, 31, and 32 listed in Section IV.E.

2. Improved multiple cropping

a. Problem addressed

Nigerien farmers most often grow millet and cowpeas (the country's predominant food crops) together rather than as single crops. They have learned from experience that, although the cowpeas may not grow as well as when planted alone, the millet almost always performs better, and the result is an overall improvement in land-use efficiency. Researchers are evaluating various crop ratios and patterns, as well as management adjustments, to obtain more efficient exploitation of the environment (nutrients, moisture and light).

Management adjustments under investigation include planting date, planting patterns, stand density, fertility and genotypes. For example, farmers normally plant millet a full month before planting intercropped cowpeas. This puts the cowpeas at an unnecessary disadvantage due to shading by the millet. Niger Cereals Research Project recommendations are for cowpeas to be planted two weeks after the millet.

Most farmers are not aware of any deficiency in the design or management of their intercropping systems.

b. Description and source

The technology consists of growing two or more crops on the same parcel of land in one season. In Niger, at least two forms of multiple cropping have been evaluated:

- Intercropping. Two or more crops grown simultaneously in some form of mixture, often in rows or bands of one crop alternated with those of another crop.

- Double cropping. Two crops grown in sequence, the second planted after harvest of the first.

Nigerien farmers have long practiced intercropping. ICRISAT and INRAN are researching the practice of double cropping, not presently used by farmers.

c. Stage of readiness for diffusion to farmers

Nigeriens have traditionally practiced intercropping extensively. Researchers can help refine this technology, however, making it more productive.

Double-cropping, on the other hand, is not widely known or practiced. It could be moved to the ready for diffusion stage with little more research, however, since it is technologically related to intercropping.

Alley cropping, another form of intercropping, has been shown to be a valuable technique in both land management and increasing crop production. Further testing, both on-station and on-farm, is needed to bring alley cropping to the ready stage in Niger.

Table 7

Stages of readiness for diffusion to farmers of technologies for improved multiple cropping. (Niger)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
1) Improved intercropping	X		
2) Double cropping		X	
3) Alley cropping			X

Scientists agree that intercropping is the preferred approach to cropping in all of Niger. Intercropping is used by farmers; scientists are advocating the use of double cropping as well.

d. Potential benefits and negative consequences

In 1985 and 1986, ICRISAT evaluated 75 different cowpea genotypes when intercropped with a standard millet cultivar. Cowpea yields ranged from 23 to 84 percent of sole crop yields, suggesting an opportunity to select genotypes specifically suited to intercropping.

In ICRISAT double cropping trials, sole cropped millet (90 day) is followed by sole-cropped cowpeas. The cowpeas do not form seed; but they do make an excellent hay that, in the opinion of several sources, is more valuable (as a cash crop) than the millet.

There are no apparent negative consequences from appropriately used improved multiple cropping in Niger.

e. Constraints to increased farmer adoption

Agricultural:

* Intercropping is already practiced; refinements and improved species will likely be readily accepted by farmers. Further research on double and alley cropping is needed to bring them to the ready for diffusion stage.

Institutional:

* Other than research and diffusion, few institutional constraints appear evident for either improved traditional intercropping or double-cropping. Alley cropping, however, could be constrained because of the possible need of involving the forestry service in the production and distribution of tree seedlings to farmers for use in some types of alley cropping.

Socioeconomic:

* The major socioeconomic constraint to both double-cropping and alley cropping is an increased demand on labor. Additionally, alley cropping with herbaceous species, would most likely involve the purchase and maintenance cost of the seedlings.

* According to several scientists, farmers would rather grow cowpeas for seed than for hay. In the perception of the farmer, growing cowpeas and selling the seed is a better economic alternative than growing them for hay. Apparently, however, some varieties are presently grown from which no seeds are harvested.

f. Issues for further consideration

* Intercropping tree crops with cereals or forages is being evaluated. This "alley cropping" research,just started, includes monitoring windbreak value, nutritional and forage content of tree trimmings, N fixation by leguminous trees, water competition, fuel production, etc. The scientific opinion is that this form of intercropping has a definite future in the Sahel.

* Scientists recommend that all of the native sahelian tree species, particularly the nitrogen fixers, be collected and evaluated for use in alley cropping systems. A complete inventory of indigenous trees has not yet been made.

g. Information sources

See Contact and Reference Nos. 3, 8, 9, 15, 16, 18, 22, 29, and 31 listed in Section IV.E.

3. Using animal traction

a. Problem addressed

Animal power increases crop productivity by improving both the quality and the timeliness of field operations. Farmers are fully aware of the value of animals, and, according to sources interviewed, would use them if they could afford to do so.

b. Description and source

The technology consists of using animals to perform operations that either cannot be done by hand (such as plowing or ridging) or that can be done much more quickly and easily by animals. Its principal sources are research in on-farm trials and village level training in Niger.

c. Stage of readiness for diffusion to farmers

While animal traction, with all of its components, has been shown to be agriculturally sound, the high economic and institutional costs associated with it limit its widespread adoption in the near future.

Table 8

Stages of readiness for diffusion to farmers of animal traction technologies. (Niger)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
1) Animal			X
2) Tools and devices			X

The technology is more appropriate for the heavier and more fertile soils near the Nigerian border, but definitely advantageous on many of the lighter soils and (in the case of weeding) for all cropped soils in Niger.

d. Potential benefits and negative consequences

Millet yields were increased from 800 to 1100 kg/ha (38 percent) by soil ridging alone (see following section, Implement Tillage) in 1986 ICRISAT trials. With respect to the economy of keeping and using animals, ICRISAT reported a growing season labor savings of 60 percent.

Unfortunately, animal traction is a luxury that most Nigerien

farmers cannot afford. Much Nigerien research has recently focused on simplifying and decreasing the cost of animal inputs by: developing lighter, cheaper, more efficient tools that can be pulled by one animal instead of two; developing better yokes and tool bars; and developing animal-powered devices such as pumps, grinding mills, freight carts, etc., that provide off-season outlets for animal power (The cost of purchasing and maintaining a draft animal for the entire year, when it is only used during the three-month cropping season, has been prohibitive.)

e. Constraints to increased farmer adoption

Agricultural:

* Mechanical development and on-farm testing remain to be done.

Institutional:

* There is a lack of credit available for buying animals and equipment.

* There is a lack of adequately trained farmers who have the capacity or ability to train other farmers how to use the technology package.

* The question of developing an adequate veterinary and maintenance infrastructure also exists.

Socioeconomic

* Use of animals for tillage is constrained by the lack of money to buy the animals, and the cost and risk involved in keeping the animal for a year while only working it for three or four months. Possibilities for decreasing costs are discussed in the Section that follows.

* Equipment is available for animal-powered seeding and weeding, as well as plowing, but lack of money for purchase and maintenance is a constraint limiting the farmer to available family labor.

* There is also a problem of providing adequate fodder and water for the animals, especially during the dry season. Learning new farming practices is not an easy process for farmers faced with risk problems.

f. Issues for further consideration

* ICRISAT researchers recommend that only heifers and cows be maintained as draft animals, and that bullocks be fattened and eaten or sold. Cows are less powerful than bullocks, but can do the job -- they are used in all of ICRISAT's experiments. Cows cost less to maintain, and provide milk and calves as well as

work. For the most part, however, farmers use only bullocks for animal traction -- cultural barriers apparently prevent the use of cows for work at present.

* The concept of making and storing hay to help sustain cows is just being considered in Niger (see Section IV.B.5, Forage Production). Additional study of available markets and returns from growing hay for sale, as well as advantages of hay for maintenance of draft animals, coupled with communication of such information to the farmer could have impact on both animal use and forage production.

g. Information sources

See Contact and Reference Nos. 2, 3, 8, 9, 13, 16, and 31 listed in Section IV.E.

4. Implement tillage

a. Problem addressed

Most of Niger's fields are tilled by hand, or are left untilled. Research demonstrates a positive effect of implement tillage on grain yields, but the strongest incentive for implement use is reduced labor demands. Weeds are a great problem and weeding comprises the largest single field operation. Deep tillage and ridging increase water retention, improve seedbed preparation and reduce weed competition with crops.

Farmers are fully aware of the value of implement tillage, as indicated for the Animal Traction technology.

b. Description and source

The technology consists of using animal-drawn implements to till the soil, thereby enhancing crop productivity due to improved seedbed, improved water infiltration, improved fertility, reduced impact of blowing sand, and reduced weed growth. At least three types of primary tillage are considered (in order of descending draft requirements): plowing, ridging (See description below), and surface scarification (with a harrow or cultivator). A cultivator is used for weeding.

A major source of this technology is from research in Niger using equipment developed in the Sahel.

c. Stage of readiness for diffusion to farmers

Since implement tillage employs animal traction, similar constraints limit both technologies, namely, high costs.

Table 9

Stages of readiness for diffusion to farmers of implement tillage technologies. (Niger)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
1) Plowing			X
2) Cultivating			X
3) Ridging			X
4) Scarifying			X

This technology appears most appropriate for the heavier and more fertile soils near the Nigerian border, but definitely advantageous on many of the lighter soils, and for weeding all of the cropped soils in Niger.

d. Potential benefits and negative consequences

ICRISAT scientists are particularly supportive of a new tillage approach called soil ridging on which the USAID/NDD project has been working in cooperation with ICRISAT.

Ridging simply consists of pulling a plow along the contour, first across the field and then back again, so that the two plow molds are pitched into each other. The resulting ridges are spaced one meter apart. The soil is ridged prior to planting, soon after receiving at least 5 mm of rain (enough moisture to allow the soil to hold itself into the formed ridge); and seeds are planted into the top of the ridge at normal stand densities. Plants growing in ridges, as opposed to flat soil or in between ridges, are stronger and can better withstand brief dry spells and blowing sand. Results of 1986 ICRISAT ridging studies with millet are summarized in Table 10 below.

Table 10

Results of 1986 ICRISAT ridging studies with millet. (Niger)

Treatment	Grain Yield	Water-Use Efficiency	Weed Levels	Draft Requirement
	----------%----------			------N*-------
Zero till	100	100	100	0
Plow	103	106	52	1995
Ridge	123	129	73	1075

* (Newtons)

e. Constraints to increased farmer adoption

Agricultural:

* Few, if any, agricultural constraints appear to exist.

Institutional:

* Institutional constraints for using implement tillage would be much the same as for using animal traction (See Section IV.B.3).

Socioeconomic:

* Lack of resources for purchase and maintenance of animals and implements; and necessity to learn a new set of farming practices.

f. Issues for further consideration

* Issues related to implement tillage are for the most part derived from those concerning use of animal traction.

g. Information sources

See Contact and Reference Nos. 8, 9, 10, 13, 15, 16, 31, and 32 listed in Section IV.E.

5. Forage production

a. Problem addressed

There is no apparent emphasis on forage production in Niger at present in spite of the fact that good quality forage commands a top price, especially in the urban areas. People purchase forages to maintain small ruminants and cattle for sale or consumption. Both cowpeas and peanuts are valued for their forage as well as their grain. Although their high protein forages are prized in the markets -- the value of the forage often exceeds that of the grain even when the crop is grown for grain -- neither crop is grown uniquely as a forage. The situation is puzzling.

Researchers in Niger agree that the time has arrived for forage improvement and exploitation, a trend based partly on current interest in using animals for draft purposes (see Section IV.B.3, Using Animal Traction). This conclusion should be checked in the field to obtain farmers' perceptions.

A major constraint to using animals is a lack of adequate feed to maintain them through the dry season. Most cattle are presently fed millet stover which has little nutritive value. Although bundles of grass hay are occasionally stacked in trees, grasses are, for the most part, mismanaged and left to dry and shatter in the blowing sand.

Farmers, especially those who own animals, are well aware of the lack of good forage.

b. Description and source

The technology consists of cultivating plants (and/or managing natural stands of plants) to be used for animal consumption. Forages can be grazed directly, or harvested, cured, and stored for later use. At least three approaches to forage production appear ready for development: improved management of natural species; introduction of new crops; and managing grain crops as forages.

Research and observations in Niger can provide a base on which to develop forage production.

c. Stage of readiness for diffusion to farmers

When available, farmers have traditionally put aside some hay for forage. With more knowledge and the increasing income value of forage, Nigeriens will likely increase forage production both for their own use and for sale. Given this situation, new forage crops are promising, but will require more research to determine the varieties best suited to Nigerien conditions.

Table 11

Stages of readiness for diffusion to farmers of forage production technologies. (Niger)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
1) Management of natural species		X	
2) Introduction of new forages			X
3) Grain crops for forages			X

Forage production is adapted and potentially appropriate for virtually all of Niger's arable land.

d. Potential benefits and negative consequences

* Sample comments from researchers in Niger:

"Farmers should be helped to appreciate the value and proper management of hay."

"Cowpea has a tremendous, yet-to-be-exploited potential as a hay. What is needed are some good dual-purpose (grain and forage) varieties."

"Sorghum is grown in limited quantities as a forage, but this should be increased."

"Someone should investigate the harvesting of millet (complete with the grain) as a hay."

"Several wild species appear to have great potential as forages (particularly Andropogon and Echinchloa). Their proper management should be researched. Some perennials could be cut twice. Mesquite seems to make a decent forage."

"The culture and management of wild forbs and shrubs for small ruminants should be investigated. Existing natural species should be evaluated so farmers will know which ones to protect and encourage, and which to cull."

"Forage species from around the world should be evaluated in Niger. There are likely several species that would prosper and make a contribution."

"The NDD project is investigating planting forage in diguettes (a water harvesting technique) and planting forage around the water

holes."

* Attention should be given to preventing exotic forage species from becoming potential pests or creating future ecological problems.

e. Constraints to increased farmer adoption

Agricultural:

* Forage production would necessitate the acquisition of some new tools, but no implements.

Institutional:

* A widespread increase in forage production could possibly be hampered by lack of sufficient transportation facilities to and from markets.

Socioeconomic:

* Increased forage production would result in increased labor demands.

f. Issues for further consideration

* Stylosouthes hamata, a new forage species has been introduced into Niger via ICRISAT. "Stylo" is a perennial legume that, if properly managed, stays alive and produces seed during the dry season. It produces up to 12 times the number of N-fixing nodules as does cowpeas. It is presently being evaluated for intercropping with millet.

* Increased forage production should be closely tied to the animal husbandry practice of penning animals, rather than letting them forage freely as is the traditional custom. This combined technology of feeding forage to penned animals would require an important cultural change, but one to be encouraged.

g. Information sources

See Contact and Reference Nos. 2, 3, 8, 10, 11, 13, 15, 16, 17, 18, 22, 29, 31, and 32 listed in Section IV.E.

6. Weather-responsive crop management

a. Problem addressed

The onset (date) of the true rainy season in the Sahel is unpredictable, and false starts are common. The result is farmer uncertainty, frequent replantings, and/or missed opportunities by failing to invest inputs into a season that develops into a "good one".

Farmers are annually confronted with, and thus are critically aware of, the problem.

b. Description and source

The technology consists of noting trends in historical rainfall data and using these trends to adjust to present rainfall events. For example, by studying long term rainfall patterns for 58 locations in Burkino Faso and Niger, ICRISAT scientists have noted a strong association between the onset of rains and the length of the growing season. An early onset usually results in a longer growing season, while delayed onset results in a shorter growing season. Knowing of this association, a farmer could observe the date of the onset of rains in his area, compare it to the long term average commencement date, and adjust his cropping decisions accordingly.

The source of this technology is ICRISAT research in the Sahel.

c. Stage of readiness for diffusion to farmers

Table 12

Stage of readiness for diffusion to farmers of technology for weather-responsive crop management. (Niger)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
Weather-responsive crop management			X

Weather-responsive crop management is apparently potentially appropriate for all of the Sahel.

d. Potential benefits and negative consequences

If a farmer could have some fore-knowledge of the length of the upcoming growing season, he could adjust his cropping decisions (primarily season-length of cultivar) accordingly. The result would be to minimize the effects of drought by making the most efficient use of the scarce rainfall in a drought year, but maxi-

mizing production in good years by exploiting the longer growing season.

e. Constraints to increased farmer adoption

Agricultural:

* The greatest constraint to weather-responsive farming is that farmers do not have seeds of variable-maturing varieties on reserve. When a change in season length appears probable, many farmers would switch to a different maturing variety if they could. It would be possible to implement response farming with cowpeas for intercropping, however, since cowpeas are planted later than millet allowing for more flexibility.

Socioeconomic:

* Socioeconomic constraints appear minimal, except that to base a planting decision on when the rains come is a departure from the past and will require some adjustment in the farmer's thinking and planning patterns. There may be some risk potential to small farmers in this technology.

f. Issues for further consideration

Three issues would appear to be critical to the success of introducing weather-responsive crop management:

* the extent to which the technology can be refined to maintain high predictability for varying microclimates as well as broad ecological zones;

* the extent to which seed of varieties of varying season length can be made available to farmers on short notice; and

* the extent to which farmers become aware of, accept, and learn how to use this type of weather information in managing their crop.

g. Information sources

See Contact and Reference Nos. 8, 9, 16, 30, and 31 listed in Section IV.E.

7. Striga control

a. Problem addressed

Striga is a parasitic weed that attacks all cereals and is extremely devastating to maize, millet, and sorghum. It attaches itself to the roots of the host, robbing the plant of water and nutrients. Each Striga plant can produce up to 1 million tiny seeds, which are easily dispersed, and lie dormant in the soil for years, germinating only if stimulated to do so by the presence of a host. Striga is rated the major cereals pest in Niger.

Farmers are well aware of the Striga problem.

b. Description and source

The current strategy to combat Striga is a combination of host resistance and improved management. The search for genetic resistance has been disappointing. Management consists of rotation with trap crops (crops that germinate Striga seed, but do not serve as suitable hosts) such as cotton and peanuts.

A sorghum variety that is resistant to Striga was imported from Sudan and tested intensively by the Niger Cereals Research Project (USAID-NCR). A new trap crop that appears to have promise was imported from Colombia, and has been used in ICRISAT Research trials.

c. Stage of readiness for diffusion to farmers

Plant breeders on the Niger Cereals Research Project have, for two years, been growing a Striga-resistant sorghum variety imported from Sudan. The variety performs well in Niger, does not appear susceptible to local diseases or bird damage, and is maturity adapted. According to researchers working with the variety, it has made a favorable impression on farmers when grown on sites heavily infested with Striga.

Agronomists at ICRISAT have identified a perennial legume (see Stylosouthes hamata, Section IV.B.5, Forage Production) that appears to be an effective Striga trap crop. It seems particularly compatible with millet, whereas cotton and peanuts are not often grown in millet areas.

Researchers still need to demonstrate these two technologies adequately in field trials; responsibilities for doing so are not clearly defined.

With adequate field testing, these technologies are potentially appropriate for cereal growing areas of Niger.

Table 13

Stages of readiness for diffusion to farmers of technologies for Striga control. (Niger)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
1) Resistant sorghum		X	
2) Stylo as trap crop		X	

d. Potential benefits and negative consequences

Eradication of this devastating pest will result in increased production and income. There are no apparent negative consequences.

e. Constraints to increased farmer adoption

Institutional:

* The National Seed Program has the mandate for seed dispersion, supported by APS. The link from research to the National Seed Program is not clear, nor is it clear who has the responsibility for dispersion of the seed.

Socioeconomic:

* Until the resistant sorghum passes through on-farm and in-kitchen testing, it will not be ready for widespread use. Stylo, on the other hand, could diffuse widely and rapidly as its economic value as a forage becomes known.

f. Issues for further consideration

* Policies and mechanisms for alleviation of the institutional constraint cited above are major issues to be resolved.

g. Information sources

See Contact and Reference Nos. 9, 15, and 31 listed in Section IV.E.

8. Water harvesting

a. Problem addressed

Sahelian rains are usually scattered but intense, and much of what falls is lost to runoff. Runoff losses are aggravated by the fact that much of the soil does not have enough vegetative cover or organic matter to retain, absorb and hold much water. Thus, although rainfall adequate for crop production often falls onto an area, so little of it may be retained for growth that plants fail, even more of the scarce surface soil is washed away, and desertification intensifies.

Farmers are keenly aware of the problems of inadequate rainfall, runoff and erosion.

b. Description and source

This set of technologies consists of collecting, diverting and concentrating rainfall by means of contours, diversion channels, tied ridges, bunds, diguettes, etc. The objective(s) is/are to prevent runoff losses or/and to harvest a small quantity of rain distributed over a large area (thus inadequate for crop production) and deliver it to a small area where, because of the resulting water concentration, crops can be grown.

Technologies to combat the problem described above (i.e., to harvest and retain water) can be divided into two general groups depending primarily on whether or not the site is cultivated.

For non-cultivated (range or forest) sites, tactics that have been demonstrated to be effective in Niger include:

1) Construction of long trenches that follow the contour. Such trenches may be up to 1 km in length and 30-90 cm deep (flanked on the downhill side by a mound of the material removed during their digging). The resulting barriers not only serve as water traps, but also hold drifting soil, organic matter and seeds; and quickly support vegetative growth.

2) Construction of mini-catchments (up to 10 m in length) that direct water into a depression in which phosphate (see Section IV.B.1, Phosphate Fertilization) can be applied and crops, valuable grasses or a tree can be planted. Growth soon expands backward from the depression due to the spread of litter and soil -- and water-holding residues.

3) Spreading branches and twigs over a site that has been denuded and has an impermeable surface or crust. This serves to trap drifting litter, sand and seeds; and makes a favorable home for termites. Within as short a period as two years such sites have supported impressive stands of native grasses.

For cultivated fields, effective water trapping techniques include:

1) Tilling the soil some time prior to planting. This opens up the crusted soil surface so that rain can be absorbed once the wet season begins. Three types of tillage are recommended: plowing, ridging or scarifying (see Section IV.B.4, Implement Tillage).

2) Using a form of ridging known as tied ridges. This consists of forming small blockades or barriers across the depression left by ridging, effectively tying the ridges together (as often as every 2 or 3 meters) so that frequent catchments are established. This can be done by hand or by using a simple device attached to the plow.

Variations of all of these approaches have been tried by several research groups in Niger and other Sahelian countries. There is good agreement that the technology of water-harvesting in its various forms has been proven effective, and it is now time for widespread implementation.

c. Stage of readiness for diffusion to farmers

In spite of possible labor and organizational constraints, water-harvesting technologies have been well-tested and proven to be effective throughout the Sahel for erosion control, increased fertility and, consequently, improved crop production. Furthermore, as the simpler technologies require little or no capital inputs, water-harvesting is ready for widespread diffusion.

Table 14

Stages of readiness for diffusion to farmers of water harvesting technologies. (Niger)

Technology component	Stage of Readiness		
	Ready	Almost Ready	Promising
Water harvesting on:			
1) Cultivated fields	X		X*
2) Non-cultivated fields	X		

* Some socioeconomic constraints if done with tillage implements.

Water harvesting technologies are adapted and potentially appropriate to virtually all of Niger, especially the areas subject to or undergoing desertification.

d. Potential benefits and negative consequences

Benefits to be derived from water harvesting are included as part of the technology description above. Potential risks are minimal.

e. Constraints to increased farmer adoption

Agricultural:

* Agricultural constraints are minimal.

Institutional:

* Smaller scale water-harvesting techniques, such as demi-lines, diguettes etc., on individual farms present no significant institutional constraints.

* Larger scale techniques, such as longer trenches and contour dikes requiring rock and vegetation barriers, will require organizational leadership and assistance because: larger groups of people will be involved in construction; more sophisticated techniques must be used; and land tenure questions must be addressed due to the required investment and more permanent installations of such projects.

Socioeconomic:

* All water-harvesting techniques will require important increases on labor demand. Labor may well be a serious constraint, as these techniques are implemented most effectively during the off-season when many of the younger, more active men in the labor force are working off the farm.

* The non-availability of animal units needed for some techniques could also constrain widespread adoption.

f. Issues for further consideration

* Water harvesting technologies are available and farm-tested. Therefore, unresolved issues are related principally to how to increase their use by farmers, individually and collectively.

g. Information sources

See Contact and Reference Nos. 2, 3, 9, 13, 16, 18, 22, and 29 listed in Section IV.E.

C. Linkages of Research with Technology Transfer Institutions

A source working closely with the interface between research and extension said, "If FSR/E (Farming Systems Research/Extension) is going to make a significant contribution to technology generation and transfer in Niger, then a meaningful transformation of the communication and information transmission patterns within and between the extension and research institutions will be necessary." (42)

Research and extension functions in Niger have been assigned to the same ministry since 1984, which should facilitate communication between the entities. In reality, communication within INRAN (Institut National de Recherche Agricole du Niger) and the ministry tends to move vertically (up and down the echelons within the organization), but horizontal communication (laterally between equivalent ranks or between organizations at all levels) remains very limited.

Contacts between research and extension are still limited, although improving somewhat. Little opportunity for interaction exists aside from the recently instituted annual meetings where both come together, minimal interaction while carrying out field trials, and occasional agent visits to the research stations.

Earlier, a problem resulted from delegation to untrained extension agents of responsibility for setting up and collecting data on multi-locational trials. The agents were blamed for failure of the trials and lack of information. (35, 19) This situation appears to be improving with the increased interchange between research and extension personnel at annual meetings.

Approximately 150 personnel are assigned local extension responsibility. In addition, some of the USAID-sponsored projects have their own extension agents. Thus, although designated extension agents also have other responsibilities, Niger has a core of agents charged with extending results of research to the farmer. Also, about 30 students in degree training will be assigned to multidisciplinary Agricultural Service Teams in six of Niger's seven departments. The teams will have responsibility for establishing an effective extension service at the department level. (27)

Information circulation remains poor within extension. Furthermore, extension lacks effective methodologies, and seldom communicates a message beyond the contents of the standard INRAN technical package. Financial and logistical resources are virtually absent except where supported by outside funds.(42)

Material and information provided by INRAN have been serious problems for extension agents. In the first place, extension agents at all levels are poorly prepared to receive and pass on research findings. (27) This problem is exacerbated by the fact that pro-

duction packages developed by INRAN and provided to extension agents have not been evaluated under on-farm conditions. (32) This places extension agents in the position of convincing farmers to adopt what is essentially a uniform nationwide package of technology. (35, 42) If farmers find it unsuitable, they blame the extension agents.

INRAN has been the subject of two recent institutional reviews; one a joint INRAN-ISNAR review, the other a background study for a proposed Applied Agricultural Research Project. Both reviews conclude that INRAN should improve outreach to its clients, and recommend that "down-stream" linkages to extension and ONAHA (National Office for Irrigated Perimeters) be reinforced and formalized. (42)

The Extension Support Center (ESC) (see Figure 1, Appendix E) established through the APS project to work on these kinds of concerns, and to upgrade extension, has been in operation about one year. The ESC has operated with the philosophy that it is not the structures of the organizations that needs changing, but that the volume and quality of communication within and between them need improvement. Consequently, the ESC has focused its early efforts on information, communication, and training. (19, 20, 42) As the National Extension Service branch assigned planning and analysis functions, the ESC is, in effect, the major national contributor to the conceptualization and implementation of extension programs in Niger. (19, 42)

ESC's work with extension has been aimed at developing a more diagnostic role for extension agents, with attention given to their ability to localize information to farmers. Training has attempted to provide the extension agents with a better understanding of their role as educators.

Mass media is accessible and well developed in Niger. The APS project has made some use of mass media, but no specific effort exists to supplement the work of the extension agents with specific mass media approaches. (19, 20, 42)

According to USAID/Niger (1), with termination of the NCR Project, the effort to improve the interface between research and extension will be transferred to the new USAID-INRAN Support Project.

D. Diffusion of Technology to Farmers

In addition to identifying and categorizing agricultural technologies in the collaborating countries, the study team's scope of work also included providing recommendations for improving diffusion of ready and almost ready technologies. Important constraints to information flow were identified that apply to the communication of all agricultural technologies within the Niger system.

1. Technology Transfer System

There is need for both formal and informal linkages that allow for ongoing two-way communication between farmers and researchers. Structuring communication into an organization or system is useful, but does not assure results. The people involved must be motivated to participate in information exchange and willing to change their behavior as a result before successful communication can occur. For example, researchers must be sincerely receptive to feedback and input from farmers before farmers' views can seriously impact research priorities. Similarly, research results must be localized, packaged and transmitted in culturally sensitive ways before farmers will find them meaningful and worthy of adoption.

Farmer-extension-research linkages and information exchange are still tenuous and of limited effectiveness. Nevertheless, the Niger technology transfer system has strengths that provide an opportunity to enhance information flow and technology diffusion, such as:

- Niger has about 150 extension agents, dispersed throughout the country, who are charged with working with farmers. Research and Extension are in the same ministry and meet together annually. This offers some opportunity for contact and communication, comparing favorably with countries where no planned research-extension contact or core of extension personnel exists.

- The training and research-extension liaison sections of the ESC (Extension Support Center) have laid some needed groundwork in increasing communication between research and extension, and helping extension agents better understand and perform an educational role with farmers.

- Research-based technologies appropriate for Niger exist, even though there are presently constraints to their adoption. An agricultural research organization (INRAN) is functioning; and other ministries, such as Planning and Livestock and Hydrology, also generate agriculturally related research results. Projects supported by international donor agencies (including USAID and ICRISAT) conduct in-country research.

- Mass media are well developed in Niger, and offer means of reaching a large share of the Nigerien population. ORTN (The National Office for Radio and Television) claims that television reaches 80 percent of the nation. Radio is accessible throughout the nation.

2. Recommendations for improving diffusion

1) As the Agricultural Production Support Project comes to a close and the Extension Support Center becomes a part of the new INRAN Support Project headquartered within INRAN (1), an

opportunity exists to build on the groundwork laid by the APS project.

Many of the technologies evaluated have need for communication of management information underlying the use of the technology. For the farmer to learn needed management skills, he must have access to a knowledgeable, reliable source of information. The NCR-APS project has outlined a more educational role for extension agents, and initiated training to assist agents in diagnosing farmers' problems and localizing information. These efforts should be continued to build purposeful communication linkages between research, extension and the farm.

ICRISAT has developed a series of recommendations or optional technologies whose components consist of:

- Phosphate fertilization
- Ridging, using animal traction
- Improved varieties of millet
- Weeding, using a cow, donkey, or bullock
- Legume rotation, rotating intercrop and pure stand

Representatives of ICRISAT and others (8 ,9) indicate they are attempting to refine their recommendations by ecological zones. The Farming Systems Research with INRAN should further help localize technical recommendations.

This series of optional technologies with their underlying management practices, localized and field tested as much as possible, should be used as the basis for developing a series of useful modules or packages for training extension agents. They should also furnish a general base of material for educational use in mass media. Suggestions to the extension agent on collecting and utilizing additional local information should be included with the training modules.

2) Research results originate from several valuable sources in Niger, but not enough provision has been made for communicating findings among these entities. Improved communication among these sources could be advantageous to all, especially the Nigerien farmer.

3) Increased consideration should be given to the potential role of mass media in agricultural information flow to reinforce and supplement extension agents' efforts in working directly with the farmer. With careful planning and design, the use of the professional recording and video-taping equipment in ESC could do more to support diffusion of agricultural technology. In addition, radio should figure more prominently in mass media strategies for diffusion.

E. Contacts and References

1. CTTA Team contacts

USAID (United States Agency for International Development)

1. Ernest F. Gibson, Senior Agricultural Development Officer
2. Marc P. Madland, Project Officer, Niamey Department Development Project, and Integrated Livestock Production Project
3. Flynn Fuller, Project Officer, Niger Cereals Research Project
4. Kevin Mullally, Agricultural Development Officer
5. Dennis Panther, Project Officer, Forestry and Land Use Planning Project, and AGRHYMET
6. Dayton Maxwell, Project Development Officer

INRAN (Institut National de Recherche Agricole du Niger)

7. Idrissa Soumana, Directeur General

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)

8. Ronald Gibbons, Executive Director, West African Programs, and Director, ICRISAT Sahelian Center
9. Charles Renard, Agronomist, Team Leader, Cropping Systems
10. Phil Serefini, Research Farm Manager
11. S. O. Okiror, Principal Millet Breeder, Regional Trials
12. Bonny R. Ntare, Breeder/Agronomist

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13. Ken Koehn, Chief of Party
14. Roman Imboden, Agricultural Machinery Expert, ARMA

NCR (Niger Cereals Research)

15. John Clark, Chief of Party
16. Chandra Reddy, Agronomist
17. John Lameris, Agronomist

APS (Agricultural Production Support Project)

18. John Mullinex, Chief of Party

19. Frederick Sowers, Training

20. Gonzalo Romero, Research-Extension Liaison

FLUP (Forestry and Land Use Planning)

21. John Heermans, Forester

22. Greg Minnick, Forester

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45. Soussou Moussa, Chef de Departement Formation

46. Ibrahim Abdou, Assistant to Secretary General

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47. Anada Tiega, Directeur-adjoint des Forêts et Faune

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48. Salissou Aboubacar, Chef, Departement Socio-economique

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Appendix 1

ACTIVITY PLAN

APPENDIX 1

Communication for Technology Transfer in Agriculture
(AID/S&T Project 936-5826)

C T T A

ACTIVITY PLAN

for

Identification and Assessment of Stage of Readiness for Diffusion to Farmers of Agricultural Technologies and Technology Systems in Selected African Countries

Prepared by:

Howard E. Ray, PhD
CTTA Project Director
Academy for Educational Development

The Communication for Technology Transfer in Agriculture (CTTA) Project is jointly managed and funded by the Offices of Education, Agriculture, and Rural Development of the Bureau for Science and Technology of the United States Agency for International Development in collaboration with Regional Bureau Technical Staff and the USAID Mission at each collaborating site. Technical services are provided by the Academy for Educational Development under Contract No. DPE-5826-C-00-5054-00. This activity is partially funded under a grant from the Small Activities Project of the Bureau for Science and Technology.

I. ACTIVITY TITLE

Identification and Assessment of Stage of Readiness for Diffusion of Agricultural Technologies and Technology Systems in Selected African Countries.

II. FUNDING

Funding is provided through a grant from the Small Activities Project of AID/S&T, supplemented with other CTTA Project funds.

III. PRINCIPAL INVESTIGATOR

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CTTA Project Director
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IV. ACTIVITY PURPOSE

To survey agricultural technologies appropriate for farmer-managed systems of mixed farmers in selected African countries that are available from national, international and regional research institutions and programs, but that have not been adopted or are presently underutilized by those farmers. The objective will be to identify and categorize those that are:

1) Ready for diffusion

"Ready" technologies are those that could be adopted immediately and beneficially by farmers within their own constraints and the existing institutional framework. It is presumed that lack of adoption to date is due primarily to lack of information, understanding and/or motivation on the part of the farmers for whom they would be appropriate.

2) Almost ready for diffusion

"Almost ready" technologies are those that have been proven technologically, but that require some additional research to determine local adaptation and/or moderate modifications in institutions, institutional support and/or policies to enable farmers to adopt them beneficially. Technologies placed in this category should be limited to those for which it is realistic to expect that they can be shifted to the "Ready" category within a period of two to four years.

In addition, technologies brought to the attention of the team that appear promising for the future will be noted and described

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in anecdotal form. "Promising" technologies are those that will require substantive additional research and/or institutional modification before they can be adopted and used beneficially by farmers. It would be unrealistic in most cases to expect that they will be ready for widespread diffusion in less than four or five years.

The term "technologies" includes both single technologies and technology systems. For the purposes of the study, a single technology is defined as a specific practice or input into a single enterprise (e.g., control measures for a given pest, an improved crop variety, or seedbed preparation technique). A technology system is defined as multi-component series of interrelated actions, practices, etc. (e.g., a farming system including mixed livestock/crop systems, alley cropping, the complete production cycle for a given crop).

V. COUNTRIES TO BE SURVEYED

Up to four African countries will be included in the survey. Those presently under consideration include:

Niger	The Gambia
Senegal	Cameroon

Other countries may also be considered during the country selection process. Final selection will be dependent upon USAID Mission interest.

VI. SURVEY STRUCTURE

A. Team Composition

The survey will be conducted by an interdisciplinary team of three to four senior scientists with extensive African experience selected by the Academy in consultation with the CTTA Project Manager and Co-Managers in the AID/S&T Offices of Education, Rural Development and Agriculture; and the Chief, Agricultural and Rural Development, AID/AFR/TR/ARD. Collectively, the team will represent expertise and experience in:

Agricultural Communications
Agricultural Research
Agricultural Economics
Social Sciences (sociology/behavioral science)
Agricultural Institutions

It is anticipated that a representative of AID/AFR/TR/ARD will be included on the survey team.

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B. Data Collection

Information will be collected and recorded systematically to facilitate comparisons between factors relating to a given technology as well as between technologies, both within and between countries. (See Appendix A, Section V.)

The stage of readiness for diffusion (as defined in Section IV) to farmers of new or currently underutilized technologies will be assessed on the basis of three critical sets of criteria:

1) Agricultural factors (technological viability),

2) Socioeconomic factors (economic and risk viability, and farmer orientation),

3) Institutional factors (policy and infrastructural adequacy).

An illustrative list of factors to be considered under each of these sets is presented in Appendix A, Section VII.

VII. EXPECTED OUTCOMES

It is expected that the study will, within each country:

- identify and categorize "ready" and "almost ready" technologies generated by national research systems, International Agricultural Research Centers (IARCs), other regional or international institutions and programs, and progressive farmers that have potential for increasing production and/or profits of farmers in specific eco-systems;

- provide information concerning current status of "almost ready" technologies that can serve as a basis for assessing progress over time in moving them to the "ready" stage;

- identify technological, institutional and socioeconomic constraints that must be addressed to move "almost ready" technologies to the point of being ready for diffusion.

- provide recommendations for improving diffusion of technologies in the ready or almost ready categories.

Although the survey team will make preliminary assessments of technologies identified, time constraints will not permit adequate examination of all relevant factors and issues. Those requiring additional study and analysis will be identified to facilitate planning future studies.

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Results of the survey will provide the basis for later in-depth studies by CTTA of the technologies, farmers and institutions in countries with which CTTA ultimately collaborates. Such investigations are essential to obtaining the information and understandings needed for developing localized, farmer-oriented communication strategies and programs that effectively support extension and other technology transfer programs.

VIII. METHODOLOGY

A. Selection of Countries to be Surveyed

1. AFR/TR/ARD will call selected USAID Missions to explain the activity purpose and approach and to solicit Mission interest in participating in the study.

2. The S&T/ED CTTA Project Manager will follow up by sending the Activity Plan and information on CTTA to Missions that have expressed interest.

3. The final selection of countries to be included will be made by the Principal Investigator in consultation with AFR/TR/ARD and the S&T Project Manager and Co-Managers.

B. Pre-survey Preparation

Pertinent information that already exists on countries to be studied will be compiled and made available to survey team members for their review before departing for Africa. Also, knowledgeable people that have lived and worked in these countries will be interviewed to gain the benefit of their insights.

1. USAID Missions and national agricultural research programs in the selected countries, IARCs, and U.S. information sources (e.g., AFR/TR/ARD, Devres institutional analysis study, World Bank, INTSORMIL) will be contacted to obtain reports and other documentation relevant to each country concerning:

   - Potentially appropriate, but underutilized, agricultural technologies and technology systems;
   - Input availability situation;
   - Small farmer agriculture--characteristics, constraints, potential;
   - Climate, weather, and ecological zones;
   - Demographic, cultural and social characteristics;
   - Agricultural institutions and general infrastructure;
   - Agricultural policies that impact on technology adoption;
   - National research and extension institutions and systems;
   - Regional and international research programs;
   - National technology diffusion institutions and systems;
   - Major constraints to agricultural development;
   - Higher education in agriculture;

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- Other issues relevant to technology identification and diffusion.

2. Information obtained through the above research will be used to:

   a) Prepare "country profiles" for the countries to be surveyed (see Appendix A, Sections III and IV).

   b) Make a preliminary assessment and selection of institutions and locations to be contacted by the survey team in-country (see Appendix A, Section IV).

   c) Develop a preliminary list of potentially appropriate, but presently underutilized, technologies that should be investigated by the survey team (see Appendix A, Section V).

3. The preliminary list of institutions and locations to be contacted will be referred back to the Missions for review and modification as appropriate, and cooperation of the Missions will be solicited for arranging survey team in-country schedules and identifying host country counterparts.

4. The survey team will receive advance copies of information compiled in steps 1-3, and will spend approximately three days in Washington for orientation and final planning prior to their departure for Africa.

C. <u>The Survey in Selected African Countries</u>

1. The survey will be conducted in collaboration with designated professionals in each country.

2. The survey team will spend a maximum of two weeks in each of the selected countries for data collection, observation, interaction with USAID and Host Country professionals, and interviews with farmers. (Missions will be requested to cover all or a portion of travel and related expenses of host country counterparts. If this cannot be arranged, such expenses will be covered by the Activity.)

3. Data and observations will be recorded in a standard format (see Appendix A) to facilitate analysis, cross-site comparisons and report writing.

IX. ANALYSIS AND REPORTING

A. <u>In Country</u>

A preliminary report of results and recommendations will be presented orally, and submitted to the Mission and relevant

Host Country professionals before leaving a country.

B. Analyses of Findings

Findings will be largely subjective and interpretive, although they will be expressed in quantitative terms where appropriate. As indicated earlier, information that may be obtained concerning technologies that appear promising for the future is expected to be general and anecdotal in nature.

C. Comprehensive Report

A comprehensive report of survey findings and recommendations, for which the Field Team Leader and Principal Investigator will have primary responsibility, will be submitted to S&T/ED, S&T/AG, S&T/RD, AFR/TR/ARD and the cooperating Missions within ninety days of completion of work in the field. The report will be organized approximately as follows:

Executive summary

I. Activity description

II. General conclusions and recommendations

III. Lessons learned

IV. Technology identification and assessment in _____. (Same format for each country)

A. Background and situation *
B. Relevant national, regional and international institutions and programs *
C. Agricultural technology assessment
   1. Presently underutilized technologies ready for diffusion
   2. Technologies almost ready for diffusion
   3. Technologies promising for the future--in anecdotal form as possible
D. Issues requiring additional study and analysis
   1. Technical
   2. Policy
   3. Institutional
   4. Socioeconomic
   5. Other
E. Conclusions and recommendations
   1. Stage of readiness of technologies
   2. Improving diffusion process
F. Appendices
   1. Team composition and itinerary
   2. Principal contacts
   3. Country identification sheet

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4. General information *
5. Relevant national, regional and international institutions and programs data sheets *
6. Agricultural technology assessment data sheets
7. Others as appropriate

* Will be drafted in the U.S. before the survey is undertaken, and checked in the field.

D. Seminar

A one-day seminar, with interdisciplinary participation similar to that in the 8/20/86 Planning Meeting, will be organized to review the report critically in relation to the expected outcomes projected in Section VII (participants will be provided copies for their review in advance of the seminar) before using it in CTTA site development and pilot project implementation activities.

X. FOLLOW-UP

A. Report Distribution

The final report will be distributed broadly to AID Regional Bureaus and S&T, USAID Missions, IARCs, other relevant AID-supported international and regional projects, and the CTTA network of international and domestic projects and institutions.

B. In the CTTA Project

Findings and recommendations will be used in the CTTA site development process for selection of the African countries to be considered for CTTA pilot projects. In the countries selected, they will provide the basis for identification and assessment of the specific technologies to be used in CTTA communication interventions.

XI. PROJECTED IMPLEMENTATION SCHEDULE

A.	Selection of survey team members	3-4/87
B.	Country selection	4-5/87
C.	Pre-survey preparation	4-7/87
D.	Data and information collection in field	8-9/87
E.	Submission of survey report	12/87
F.	Report review seminar	12/87

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Communication for Technology Transfer in Agriculture
(AID/S&T Project 936-5826)

C T T A

APPENDIX A

ANALYTICAL FRAMEWORK

for

Identification and Assessment of Stage of Readiness for Diffusion to Farmers of Agricultural Technologies and Technology Systems in Selected African Countries

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Revised by H. Ray to incorporate additional suggestions received subsequently from participants in the Planning Meeting for Agricultural Technology Systems Identification for Africa.