PD-AAX-818

# Technology for Soil Moisture Management Project (TSMM)

## Progress Report
## January 1984 to December 1986

Agricultural Research Service

U.S. Agency For International Development

March 1987

PRINCIPAL PERSONNEL
USDA/USAID
DRYLAND AGRICULTURE PROJECT (TSMM)

Dr. James F. Parr, USDA-ARS
Project Coordinator and
National Program Leader for Dryland
Agriculture and Soil Fertility
Beltsville, Maryland

Dr. Raymond E. Meyer, USAID/S&T/AGR
Project Monitor and Soil Scientist
Renewable Natural Resources Division
Rosslyn, Virginia

Dr. John C. Day, USDA-ERS
Resource Economist and Coordinator
for the Economic Component of TSMM
Washington, D.C.

Dr. Robert I. Papendick, USDA-ARS
Associate Project Coordinator,
Soil Scientist and Research Leader
Land and Water Conservation Research Unit
Pullman, Washington

Dr. Bobby A. Stewart, USDA-ARS
Associate Project Coordinator, Soil Scientist,
and Director, Conservation and Production
Research Laboratory
Bushland, Texas

CONTENTS


| | Page |
|---|---|
| Foreword | i |
| Summary | iii |
| Glossary | vi |
| I. Background | 1 |
| A. The Problem | 1 |
| B. Project Objectives | 1 |
| C. Project Organization | 3 |
| II. Approach | 3 |
| A. The Three Steps | 4 |
| B. Supporting Activities | 5 |
| III. Accomplishments: Asia | 6 |
| A. Northeast Thailand | 6 |
| 1. Data Bases | 6 |
| 2. Workshops | 7 |
| 3. Regional Research | 7 |
| B. Sri Lanka | 7 |
| IV. Accomplishments: Near East | 8 |
| A. Jordan | 8 |
| 1. Data Bases | 9 |
| 2. Workshops | 9 |
| 3. Regional Research | 10 |
| V. Accomplishments: Africa | 10 |
| A. Niger | 10 |
| B. Mali | 11 |
| 1. Data Bases | 11 |
| 2. Case Studies: Economic Analyses | 12 |
| C. Sudan | 12 |
| VI. Supporting Activities | 13 |
| A. Study Tours | 13 |
| 1. 1984 Tour | 13 |
| 2. 1985 Tour | 14 |
| 3. 1986 Tour | 14 |
| B. Orientation to ARS Research | 15 |
| VII. Conclusions and Recommendations | 15 |
| Annexes | |

# FOREWORD

Late in 1983, a PASA Project was agreed upon by the Agricultural Research Service (ARS) of the U.S. Department of Agriculture (USDA) and the U.S. Agency for International Development (USAID), whereby ARS would provide technical input to USAID projects for improving soil and water management in dryland or rainfed agriculture systems. This decision reflects not only a growing awareness that such systems provide most of the world's basic food crops, but that increased production is often limited by soil and water management. It also indicates renewed interest in improving the productivity of subsistence farmers in semiarid regions where dryland and rainfed agriculture is practiced. The USAID/USDA Dryland Management Project, also referred to as the Technology of Soil Moisture Management (TSMM), is directed toward three geographic regions where there is a critical need to increase the production of diversified agricultural crops: the Near East (or Middle East), sub-Saharan Africa, and Southeast Asia.

The countries in these three regions are extremely poor by western standards, both agriculturally and economically. The major constraints to increased agricultural productivity and stability are coarse-textured, sandy soils that are inherently low in fertility, low in soil organic matter, and low in their water holding capacity. Rainfall patterns are erratic and crops are subject to moisture deficits and stress from drought that can occur even during the rainy season. It is logical then that USAID should be concerned with improving soil, water and crop management systems for dryland and rainfed agriculture in these regions. We are accomplishing this by enlisting the best technical expertise in the world, developed over the past half-century by USDA's Agricultural Research Service in the U.S. Great Plains.

As a result of the PASA Project, ARS scientists and engineers are contributing greatly to strengthening ongoing USAID bilateral, regional and centrally-funded projects involving soil and water management. Project staff are currently working closely with USAID Missions, Regional Bureaus, and the Bureau for Science and Technology in helping to develop more effective and meaningful projects for the future.

The approach taken by the TSMM/PASA is unique and has been highly successful. First, a data base of past research results for a particular country is compiled and assessed for relevance to current problems. Second, regional workshops are held to provide technical input where gaps exist in the data base, which serves as a model for other participating countries. Third, cooperative regional research projects are developed to address high priority problems on soil and water management that are common to countries within a region. These "ribbon projects" serve to foster linkages of national scientists with one another and with ARS scientists in the U.S., and to forge a highly effective networking system on dryland/rainfed agriculture.

TSMM's approach merits recognition and may be useful in other areas of international agricultural development.

Dr. Anson R. Bertrand
Former Director, Office of Agriculture
Science and Technology Bureau
USAID, Washington, D.C.

## SUMMARY

Dryland areas in the Near East, sub-Saharan Africa and Southeast Asia are a major source of food and fiber for millions of people. Current yields are extremely low, compared with yields in developed countries. Existing technologies to improve dryland production are not in widespread use. Also, economic climates often fail to encourage the adoption of improved crop, soil and water management practices.

To assist farmers in dryland areas of developing countries, the U.S. Agency for International Development (AID) organized the Technology for Soil Moisture Management Project (TSMM) in 1983. TSMM is being implemented through a Participating Agency Service Agreement (PASA) between the Agricultural Research Service (ARS) of USDA and the Science and Technology Bureau (S&T) of AID. ARS has addressed problems of dryland agriculture in the U.S. Great Plains for more than 50 years. Through TSMM, the skills of scientists in ARS and in land-grant universities are being applied to arid and semiarid regions of developing countries.

The overall objective of TSMM is to assist developing countries and donor agencies to assess soil moisture and related soil fertility problems and establish national strategies for increasing the long-term productivity of dryland areas. Through a series of activities, TSMM assists with research, technology transfer, economic analyses, planning and assessments of policy needs.

TSMM's basic approach involves three steps: 1) compiling data bases or syntheses of relevant in-country research; 2) conducting workshops to assess findings and establish priorities; 3) planning and implementing regional research and economic case studies on priority problems. In the long run, TSMM hopes to contribute to the development of regional research networks in dryland soil and water management.

Activities are underway in Asia, the Near East and Africa. In Asia, TSMM has focused its efforts in Northeast Thailand. Thai scientists have synthesized existing research findings and compiled data bases. At a TSMM-sponsored workshop, scientists who previously had little communication began to work cooperatively and establish priorities for research. With TSMM's assistance, two research proposals have been prepared to initiate regional research on priority problems.

In the Near East, TSMM is working in Jordan to compile data bases on soil, water and crop management for rainfed agriculture. Seventy research scientists and policy officials from six countries participated in a workshop in January 1986 and developed a framework for collaboration and networking on research problems. In 1987, five countries in the Near East plan to use a common experimental design to study the agronomic and economic values of crop residues from rainfed wheat and barley, for soil and water conservation and for utilization by livestock.

In Africa, TSMM is cooperating with USAID/Mali to conduct a case study on the economics of improved soil and water management practices. TSMM is designing computer-based representative farm models and farm surveys to permit an economic evaluation of soil and water management technology in typical dryland areas. TSMM researchers expect the modeling framework and survey data to be applicable to other Sahelian countries, with minor modifications.

TSMM provided technical assistance to several other countries, including Sudan, Niger, Morocco, Turkey, Sri Lanka and India. Assistance included providing scientific expertise for resolving problems of soil moisture management, participating in reviews of ongoing and proposed research projects, developing problem-solving strategies, facilitating information dissemination, and promoting regional collaboration through workshops, seminars and training programs.

A prominent activity supporting TSMM is the organization of annual study tours of soil, water and crop management systems at different USDA-ARS research facilities throughout the U.S. Great Plains. These "traveling seminars" foster the exchange of information between U.S. and developing country scientists and the development of research networks.

Although TSMM is working in only a few countries, its activities are providing a model that other countries can emulate. The data bases provide valuable information for national planning and for identifying agricultural research needs and priorities. The workshops bring together government, university and international experts to assess the data base, establish priorities for future research and identify resources to address problems. Workshops foster communication and cooperation among scientists. Regional research on priority problems is being undertaken jointly by several countries, or within a framework that promotes sharing of the results.

During almost three years of activity, TSMM has enhanced communication and cooperation among scientists who are working on soil and water management problems, involving both agronomic and economic components. By integrating agronomic and economic concerns, TSMM is unique. Planners must assess both the technology and the economics of its use in order to assess options realistically.

The following recommendations emerge from TSMM experience.

- TSMM should continue to collaborate with other donors to avoid duplication of effort and ensure cost-effective and meaningful development of rainfed agriculture.

- TSMM should continue to assist in the development of data bases and workshops within specific countries, and to use these activities to build functioning regional research networks in soil and water management.

- TSMM should continue economic analyses to increase understanding of the economic implications of adoption and diffusion of new and improved soil and water management practices.

- TSMM should continue to advise donor organizations and USAID missions on the need for investing time and resources in developing more productive soil and water management systems for rainfed agriculture.

## GLOSSARY

| | |
|---|---|
| AID | Agency for International Development |
| AOAD | Arab Organization for Agricultural Development |
| ARS | Agricultural Research Service, U.S. Department of Agriculture |
| ASIR | Arab Scientific Institute for Research |
| CGIAR | Consultative Group for International Agricultural Research |
| CRSP | Collaborative Research Support Program |
| DARP | Diversified Agricultural Research Project, USAID/Sri Lanka |
| ERS | Economic Research Service, U.S. Department of Agriculture |
| FSR/E | Farming Systems Research and Extension Project, Mali |
| FAO | Food and Agriculture Organization |
| GTZ | German Technical Assistance Agency |
| IARC | International Agricultural Research Center of the CGIAR system |
| IBSRAM | International Board for Soils Research and Management |
| ICARDA | International Center for Agricultural Research in the Dryland Areas |
| ICRISAT | International Crops Research Institute for the Semi-Arid Tropics |
| IFDC | International Fertilizer Development Center |
| IITA | International Institute for Tropical Agriculture |
| ILCA | International Livestock Center for Africa |
| INRAN | National Institute for Agricultural Research in Niger |
| IRAT | Tropical Agriculture Research Institute in France |

| | |
|---|---|
| ISNAR | International Service for National Agricultural Research |
| JHADP | Jordan Highlands Agricultural Development Project |
| JUST | Jordan University of Science and Technology |
| KKU | Khon Kaen University, Thailand |
| KU | Kasetsart University, Thailand |
| MOAC | Ministry of Agriculture and Cooperatives, Thailand |
| OICD | Office of International Cooperation and Development, U.S. Department of Agriculture |
| ORSTOM | Office of Scientific Research and Technology for Mediterranean Zone (France) |
| PASA | Participating Agency Service Agreement |
| RAIN | Rainfed Agricultural Information Network, Jordan |
| RTG | Royal Thai Government, Thailand |
| SAFGRAD | Semi-Arid Food Grains Research and Development |
| S&T | Science and Technology Bureau, Agency for International Development |
| SECID | South-East Consortium for International Development |
| SCRAD | "Systematic Commodity/Resource Analysis and Development" concept |
| TROPSOILS | A Collaborative Research Support Program (CRSP) in tropical soils |
| TSMM | Technology for Soil Moisture Management |
| UOJ | University of Jordan |
| WHARF | World Hunger Alleviation through Response Farming |
| World Bank | International Bank for Reconstruction and Development |

PROGRESS REPORT

TECHNOLOGY FOR SOIL MOISTURE MANAGEMENT PROJECT (TSMM)
January 1984 to December 1986

## I. Background

### A. The Problem

In developing countries, most of the food needed for human consumption is produced on non-irrigated land. More than 500 million people inhabit the low rainfall areas of developing countries, primarily in the Near East, sub-Saharan Africa and Southeast Asia. Farmers in these regions produce more than 50 percent of the world's sorghum, almost 70 percent of the groundnuts, 80 percent of the pearl millet, 90 percent of the chickpeas, and 96 percent of the pigeon peas. For the forseeable future, these dryland areas will be the major source of food and fiber for expanding populations.

Although dryland areas in developing countries produce most of the world's food grains, yields are extremely low. In the developed world, yields on dryland areas are two to four times greater. Livestock are typically an important part of dryland farming systems, but in developing countries animal productivity is also low. Many technologies to improve productivity exist, but they are not used extensively. Government policies and programs often discourage widespread investment in improved crop, livestock and soil/water management practices.

### B. Project Objectives

To assist farmers in dryland areas of developing countries, the Agency for International Development (AID) organized the Technology for Soil Moisture Management Project (TSMM) in 1983. TSMM is being implemented through a Participating Agency Service Agreement (PASA) beween the Agricultural Research Service (ARS) of USDA and the Science and Technology Bureau of AID. ARS has addressed problems of dryland agriculture in the U.S. Great Plains for more than 50 years and has a large group of scientists and engineers with extensive experience in dryland agriculture. Through TSMM, their skills in improving soil, water and crop management systems are being applied to arid and

semiarid regions in developing countries. Many of these regions have soil and agroclimatic conditions that are similar to those in the U.S. Great Plains.

The overall objective of TSMM is to help developing countries and donor agencies assess soil moisture and related soil fertility problems and establish national strategies for increasing the long-term productivity of dryland areas.

Specific objectives are as follows:

(1) To seek ways to increase the productivity of soils and stability of cropping systems under rainfed conditions;

(2) To seeks ways to increase the retention and storage of water from existing precipitation, thereby minimizing runoff, erosion, and evaporative losses;

(3) To seek ways to increase the efficient use of water by crops through proper crop selection and sequencing, and through the use of improved crop calendars;

(4) To assess the economic impacts of improved rainfed crop and livestock production practices;

(5) To evaluate public policy and program options that would stimulate adoption and diffusion of improved rainfed production practices;

(6) To determine the benefits and costs of additional investments in dryland or rainfed production systems.

Objectives one, two and three address agronomic issues; they were part of the original project paper. Objectives four, five and six were added in 1985 to cover the economic aspects of dryland agriculture. TSMM is unique because it integrates agronomic research and economic assessment within one project. This integration facilitates the achievement of the overall objective because planners must understand both agronomic and economic issues in order to assess options realistically.

To achieve these objectives, TSMM works on a regional basis to review and assess relevant research findings, to conduct workshops that establish research priorities, and to plan and implement regional research on high priority problems. TSMM activities include providing technical assistance to resolve

problems of soil moisture management, participating in reviews of ongoing and proposed research projects, developing problem-solving strategies, facilitating information dissemination, and promoting regional collaboration through workshops, seminars and training programs. In the long run, TSMM hopes to contribute to the development of regional research networks in dryland soil and water management.

TSMM activities were initiated in countries representing the Asian, Near East and West African regions (Thailand, Jordan and Mali). Now, activities are beginning in East Africa (Sudan) and are expanding within Asia (to Sri Lanka) and West Africa (Niger).

C. Project Organization

TSMM is managed jointly by the U.S. Department of Agriculture's Agricultural Research Service (ARS) and the Office of International Cooperation and Development (OICD), with funds provided by the Agency for International Development (AID), Bureau of Science and Technology (S&T) through its Office of Agriculture.

As the implementing agency, USDA has the only staff members assigned to TSMM on a full-time basis. TSMM's Project Coordinator is located within ARS and the Economic Component Coordinator is located within USDA's Economic Research Service (ERS). USDA's Office of International Cooperation and Development (OICD) contracts with individuals and organizations for specific project assignments. Cooperative agreements are currently maintained with Texas A&M University, Iowa State University, the International Center for Arid and Semi-arid Lands Studies at Texas Tech University, Washington State University, and Utah State University. OICD contracts with other institutions, as needed. A Technical Advisory Committee composed of two representatives from ARS and two representatives from U.S. universities provides technical advice and assists with short-term overseas assignments.

From January 1984 to September 1986, total funds allocated were $1,485,000. Including short-term assignments, approximately four person-years of professional time were allocated to project activities.

II. Approach

TSMM's basic approach has evolved as team leaders responded to requests for assistance and assessed needs and opportunities. TSMM is currently working in three regions--

Southeast Asia, the Near East and sub-Saharan Africa--but has activities in only a few countries. These activities are providing a model that can be followed in other countries.

A. The Three-Steps

Although the sequencing of activities varies from country to country, TSMM's basic approach involves three steps:

- Compiling data bases of research data and information relevant to rainfed agriculture;
- Conducting workshops to assess the data base findings and to establish research needs and priorities;
- Planning and implementing regional research and economic case studies on high priority problems in rainfed agriculture.

All three steps help to identify scientists in relevant disciplines, establish linkages among them and encourage the development of research and information networks that function within individual countries and among countries within a region. Initially, TSMM activities may focus in one country within a region; later, they may expand to other countries, thereby drawing scientists from several countries into linkages, networks and collaborative research.

The task of compiling data bases involves locating relevant research on soil, water and cropping systems in a particular country and preparing a summary that reviews past research, examines ongoing research, draws conclusions from the research results, makes recommendations for future research needs and establishes research needs and priorities. Subject matter areas include: 1) soil moisture conservation; 2) conservation tillage; 3) wind and water erosion control practices; 4) farming systems/crop rotations; 5) soil fertility; 6) agroclimatology; 7) socio-economic impacts of improved management practices; 8) crop residue management; 9) water harvesting; 10) systems modeling.

Workshops bring together government, university and international experts to assess findings and conclusions of the research review, establish priorities for future research, and identify resources to address problems. Workshops try to foster a cooperative spirit among participants, provide a forum for identification of scientists who participate in regional research trials, and establish the basis for long-term scientist-to-scientist linkages.

Regional research includes both agronomic research and economic case studies. In agronomic research, scientists conduct studies on high priority problems and share results. This research establishes the foundation for a regional research network in soil and water management for rainfed agriculture.

Within a region, if there is sufficient interest, a "ribbon project" may be initiated with separate funding to link existing bilateral projects and country programs with common interests. Ribbon projects provide an opportunity for better communication, coordination and infrastructure to facilitate implementation of common experiments in a number of locations within a region. Ribbon projects thus promote regional networking for research, technology transfer and information exchange.

The economic component involves the review of soil and water management issues and related economic and policy concerns in typical dryland areas, the design and development of economic models with special features to evaluate the economics of soil and water management technology, the identification of data needed for economic analysis at farm, community and regional levels, assistance in the design of farm surveys, and various water management analyses.

B. Supporting Activities

TSMM provides technical assistance to countries interested in improving dryland/rainfed production systems. Assistance includes providing scientific expertise to resolve problems of soil moisture management, participating in reviews of ongoing and proposed research projects, developing problem-solving strategies, facilitating information dissemination, and promoting regional collaboration through workshops, seminars and training programs.

To provide opportunities for scientists to review current research on soil, water and crop management systems and to encourage network development, TSMM organizes annual study tours of USDA-ARS research facilities in the U.S. Great Plains. These "traveling seminars" are for scientists and administrators from developing countries in semiarid areas, and personnel from USDA, land-grant universities and international development agencies, including the World Bank, FAO, USAID and the CGIAR centers.

In summary, TSMM uses a three-step approach to review and assess relevant research, establish research needs and priorities at workshops, and plan and implement regional research. Technical assistance and "traveling seminars" support this approach. Subsequent chapters (III, IV and V) outline accomplishments in each of the three regions. Chapter VI explains supporting activities in detail.

## III. Accomplishments: Asia

### A. Northeast Thailand

The Northeast Region of Thailand encompasses the Korat Plateau with 17 provinces and approximately 18 million people. Most of the people are subsistence farmers, growing primarily rice. The region comprises about one-third of Thailand and is the poorest region in the country. The average net income of these farmers is less than one-half the income of Thai farmers in other regions.

The coarse, sandy soils are a major constraint to agriculture. They are inherently low in fertility, low in organic matter, low in cation exchange capacity, low in water holding capacity, and subject to extreme changes in pH during the wet and dry seasons. Twenty to thirty percent of soils have been adversely affected by salinity. Rainfall patterns are erratic and crops are subject to moisture deficits that can occur even during the rainy season.

TSMM began working in Thailand at the request of the USAID mission which was also concerned with improving rainfed agriculture in Northeast Thailand.

#### 1. Data Bases

TSMM contracted with the Department of Soil Science at Kasetsart University (KU) in Bangkok to compile a review and assessment of soil, water, and crop management systems research conducted in Thailand. A team of scientists concentrated on research that was relevant to rainfed agriculture in Northeast Thailand and had been conducted during the past ten years. They reviewed research reported in journals, workshop proceedings, bulletins, and unpublished reports of various Thai university departments and government agencies. Many documents in Thai were excerpted and translated.

The document that emerged from this effort in February 1985 is entitled "Soil, Water, Cropping Systems Research Data Bases Relevant to Rainfed Agriculture in Northeast Thailand." Separate chapters cover numerous topics relating to soil, water and crop management practices. Each chapter reviews past and ongoing research, draws conclusions from the research results and makes recommendations for future research needs and priorities. The document contains approximately 800 pages written entirely in English. It is currently out of print. However, efforts are being made to revise and reprint it in cooperation with Kasetsart University and the International Board for Soils Research and Management (IBSRAM) in Bangkok.

2. Workshops

TSMM sponsored a workshop on "Soil, Water and Crop Management Systems for Rainfed Agriculture in Northeast Thailand," at Khon Kaen University (KKU) in Khon Kaen, February 25-March 1, 1985. The data base document was distributed to participants and used to identify gaps in various subject areas and to establish priorities for future research and resource allocation. Participants included representatives from several Thai agricultural research institutions, including: Kasetsart University, Khon Kaen University, Chiang Mai University, Prince of Sonkla University, the Ministry of Agriculture and Cooperatives (MOAC) and its various departments.

A significant achievement of the workshop was its success in fostering a cooperative spirit among participants. Participating institutions had previously had little communication because of the strong centralization of Royal Thai Government (RTG) agricultural research agencies. Even within the MOAC, the two principal research services (Department of Agriculture and Department of Land Development) had little communication. A conclusion of the workshop was that the Thai universities and RTG agencies should begin to work cooperatively on high priority research projects in the Northeast Region. Specifically, research should be directed toward improving soil and water management techniques, increasing the retention and storage of water in soils, and improving the selection or sequencing of crops for more efficient use of limited amounts of water.

Annex A presents the conclusions and recommendations of the Working Groups at the workshop. The Workshop Proceedings, including technical papers, are in press.

3. Regional Research

Following the workshop, TSMM worked with the soil and plant scientists at Khon Kaen University to prepare two research proposals on priority topics: 1) "Quantifying the relative effects of water and chemical stress on fertilizer response in soils of Northeast Thailand;" and 2) "Organic amendments for alleviating water and chemical stresses in soils of Northeast Thailand."
Both proposals have been submitted to AID for funding. If implemented, they will bring work in Thailand to the third stage of the three-step approach -- regional research trials.

B. Sri Lanka

TSMM activities in Sri Lanka are also at the planning and development stage. Three representatives from the Sri Lankan Ministry of Agriculture participated in the TSMM-sponsored

workshop in Thailand in February 1985. A workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in Sri Lanka" is now in the early planning stages.

TSMM is working closely with the USAID mission. USAID recently initiated the Diversified Agricultural Research Project (DARP), to focus on the development of stable, productive, and more highly diversified agricultural production systems. Sri Lanka has recently become self-sufficient in rice, but rice quality is inadequate to compete for export markets. Through DARP, USAID and the Government of Sri Lanka will be working to shift rice-based farming systems toward increased production of food legumes, vegetables, oil seed crops and livestock forages. These changes require the implementation of sound soil and water management practices, especially in the zones where rainfall is limited. The USAID mission has urged immediate action on developing relevant data bases.

## IV. Accomplishments: Near East

### A. Jordan

In Jordan, approximately one million acres of arable land are drylands. Ninety percent of the country receives less than 200 mm of rainfall annually; the remaining ten percent has annual rainfall ranging from 250 to 600 mm. With low inputs, low investment and low yields, Jordan's dryland agriculture makes only a limited contribution to the country's economy.

In cooperation with international donors, the Government of Jordan attempted to improve the productivity of dryland agriculture through several research and agricultural projects. These projects did not produce satisfactory results, but they clearly indicated the need for a more comprehensive approach. USAID is now implementing the Jordan Highlands Agricultural Development Project (JHADP), a comprehensive and long-term effort to improve crop production and resource conservation in Jordan's agricultural areas.

In March 1985, USAID sponsored a Rainfed Agricultural Information Network (RAIN) Workshop in Amman, Jordan. This workshop identified the need for a series of technical workshops to improve dryland agriculture in the region. USAID asked TSMM to organize a workshop on soil and water management systems for rainfed agriculture in the Near East Region, as the first of the series.

1. Data Bases

At USAID's request, TSMM subcontracted with Dr. Abdullah Jaradat at Yarmouk University to compile a data base on soil, water and crop management for rainfed agriculture in Jordan. To identify future research needs and priorities, the data base reviews recent and ongoing research, examines results and assesses recommendations. It includes information on government policies in dryland areas, soil resources and conservation, agroclimatology, cultural practices, and crop rotations. Annex B presents a brief summary of progress in each of these areas. The data base document will be published early in 1987 and will be entitled "An Assessment of Research Needs and Priorities for Rainfed Agriculture in Jordan."

2. Workshops

In January 1986, TSMM and the International Center for Agricultural Research in the Dryland Areas (ICARDA) co-sponsored a workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." The workshop was held in Amman, Jordan, January 8-23. Approximately 70 participants from six countries attended the sessions. Participants included ICARDA, the regional Arab research organization (ACSAD), the University of Jordan, Yarmouk University, the Jordanian Ministry of Agriculture, the Arab Scientific Institute for Research (ASIR), the Food and Agriculture Organization (FAO), the German Technical Assistance Agency (GTZ), the Arab Organization for Agricultural Development (AOAD), the Jordan/Australian Dryland Farming Project, Jordan Agricultural Cooperative Services Organization, and the Water Authority of Jordan.

Workshop sessions included regional overviews and Jordanian research experience relevant to soil resources, water resources, agroclimatology and farming systems. U.S. experts from USDA and Title XII universities presented information on methods for studying wind and water erosion and on new and improved technologies for reducing erosion and improving soil and water management in dryland agriculture.

To analyze needs and set priorities, the workshop used the "Systematic Commodity/Resource Analysis and Development" (SCRAD) concept developed by Dr. W.R. Furtick and Dr. Takaaki Izumi at the University of Hawaii. The SCRAD process helps identify components of priority research areas, constraints for the components, actions necessary to overcome the constraints, and priorities among the recommended actions.

The workshop helped to identify outstanding Jordanian scientists that might be involved in USAID's Jordan Highlands Agricultural Development Project, thus strengthening the

in-country contribution to project activities and advancing the development of research networks on dryland agricultural problems in the Near East. Participants found that many opportunities exist to improve production in dryland areas. Technologies that could be adapted include water harvesting, crop residue management, and water conservation. Workshop proceedings will be published early in 1987.

3. Regional Research

The workshop in Jordan developed a framework for collaboration and networking on research problems of interest to a number of countries in the Near East region. It also identified a high priority topic--the need to assess the relative value of crop residues for livestock feed and for soil and water conservation.

To respond to the need for research on this topic, TSMM leaders drafted a "ribbon project." Using a common experimental design, research will be carried out in at least five countries in the Near East Region during the spring of 1987. The research will focus on the agronomic and economic values of crop residues from rainfed wheat and barley. The use of residues in soil and water conservation will be compared with their use as forage for small ruminants, mainly sheep. Details are included in Annex C.

As a spinoff of the workshop, a small network in wind erosion research has been formed. An ARS scientist collaborating with TSMM discussed wind erosion research at the workshop, then traveled to several countries to install dust samplers that he developed for wind erosion research. Collaborators at the University of Jordan, the Arid Institute in Tunisia and the Agronomy Institute in Morocco will test and validate a new wind erosion model.

## V. Accomplishments: Africa

### A. Niger

In Niger, TSMM is also in the initial planning phase. TSMM leaders selected Dr. Naraine Persaud (Texas A&M, TROPSOILS CRSP) as coordinator for compiling a research data base on soil, water and crop/livestock management systems under dryland/rainfed conditions in Niger. This data base will be used in a workshop scheduled for January 1987.

TSMM leaders developed and organized the workshop. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Texas A&M University (TROPSOILS) and the National Institute for Agricultural Research in Niger (INRAN) are co-sponsors. Other international centers participating are:

International Service for National Agricultural Research (ISNAR); International Livestock Center for Africa (ILCA); International Institute for Tropical Agriculture (IITA); International Center for Agricultural Research in the Dry Areas (ICARDA); International Fertilizer Development Center (IFDC). Participating organizations also include Semi-Arid Food Grains Research and Development (SAFGRAD), Washington State University, Purdue University, Jordan University of Science and Technology (JUST), the Tropical Agriculture Research Institute in France (IRAT), Office of Scientific Research and Technology for Mediterranean Zone in France (ORSTOM), World Hunger Alleviation through Response Farming (WHARF), and the University of Paris.

## B. Mali

Mali is one of the largest and poorest countries of western Africa. It has a population of almost seven million and an area of 1.2 million square kilometers. Rainfall is highly variable in occurrence and intensity. In the south, approximately 30 percent of the land area receives 500 to 1500 mm of rainfall per year. Another 30 percent of land area receives 250 to 500 mm of rainfall per year. The remainder of the country, in the north, is barren desert, with virtually no settled habitation.

In the cropped area of Mali, soils are primarily ferruginous tropical and hydromorphic. Some are sandy and low in organic matter, with crust outcroppings and shallow depth. Others were formed on flood plains and in depressions and are higher in clay and organic matter.

TSMM began working in Mali at the request of the USAID mission. The mission, in cooperation with the Government of Mali and other donor agencies, has in place a country development strategy and project portfolio that emphasizes the improvement of dryland agriculture.

### 1. Data Bases

TSMM staff have proposed that previous research findings on soil, water and crop management in Mali be systematically reviewed and summarized. Data bases created by this process could assist national planning for the management, conservation and protection of natural resources and be helpful in the planning and implementation of many new agricultural development projects that the USAID mission has underway. They would also be useful in the TSMM case study of the economic aspects of soil and water management technologies in Mali (discussed in the following section). A draft outline of the proposed data bases has been submitted to the USAID mission for review and discussion (see Annex D). A decision on implementation is expected soon.

## 2. Case Studies: Economic Analyses

TSMM is cooperating with USAID/Mali to conduct case studies on the economics of improved dryland technology. Mali was chosen as a representative situation. Mali's basic agro-climatic conditions and farming systems are similar to those of other countries of the Sahel region. Beginning in 1985, TSMM reviewed relevant literature and summarized current thinking regarding soil and water management and related economic and policy concerns. In cooperation with the Michigan State University Food Security Project and other research programs in Mali, TSMM is conducting comparative analyses at the farm level on resources, soil and water management technologies, production responses, and economic relationships.

In 1986, USAID/Mali initiated a large farming systems research and extension project (FSR/E), a ten-year, $20 million effort with the South-East Consortium for International Development (SECID) as prime contractor. Since the overall goals of TSMM's case study and FSR/E are similar, the two projects will be collaborating. TSMM is now working with SECID project managers and the FSR/E team to design and develop computer-based, representative farm models that incorporate special features needed for the economic evaluation of soil and water management technology in typical dryland areas. One model has been designed, tested and installed on a portable personal computer (PC). In connection with these analyses, TSMM evaluated portable PCs for suitability in overseas technical work. Two Panasonic Exec-Partner PCs were purchased for use in Mali and one IBM PC-AT was purchased for U.S.-based analyses.

TSMM is identifying information needed for analysis at the farm, community and regional levels, and is also assisting in the design of questionnaires for farm surveys that FSR/E plans to carry out next season. TSMM researchers expect that the modeling framework and technical data will be applicable to other Sahelian countries with only marginal modifications.

## C. Sudan

At the request of the Government of Sudan and the USAID mission in Khartoum, TSMM is assisting with a soil and water management program for the mechanized rainfed sector . The objective is to improve rainfed crop production. TSMM is using the research experience of TROPSOILS in West Africa. TROPSOILS is a Collaborative Research Support Program (CRSP), wherein research is undertaken by land grant universities with AID funds, in support of development. TSMM is merging the experience of TROPSOILS with U.S. research and extension experience in similar areas of the Texas Blackland Prairies for application to Sudan.

As a result of activities to date, two manuscripts have been written. One concerns optimal farm plans, including risk aversion. The other examines risk programming approaches to modeling dryland farming. (See Annex E: Rashid and D'Silva.) Other TSMM activities were suspended when political events caused a complete dismantling of AID's program in Sudan.

## VI. Supporting Activities

### A. Study Tours

During 1984, 1985 and 1986, TSMM organized study tours or "travelling seminars" of dryland/rainfed farming systems in the U.S. Great Plains. These seminars are a major impetus in the development of scientist-to-scientist linkages and networks. Farmers in the Great Plains must deal with many of the same problems that exist in other arid and semiarid regions of the world. During a one or two-week period, each study tour introduces participants to recent research on soil, water and crop management at different USDA-ARS research facilities throughout the U.S. Great Plains. Participants include: scientists from developing countries in semiarid regions; personnel from international agricultural research centers (IARCs) and international development agencies (e.g. FAO, World Bank, USAID); and personnel from Title XII universities and USDA.

Each seminar highlighted the unique way in which the researcher, the extension agent and farmers interact in the U.S. agricultural research-extension delivery system. The farmer feedback system that U.S. scientists take for granted has been of tremendous interest to tour participants from developing countries.

Tours foster a two-way exchange of information. U.S. agricultural scientists receive valuable information from scientists in developing countries, for example, on germplasm selections for millet and sorghum, agroforestry, and alternative crops. Agricultural scientists from the developing world learn about current research and the latest technologies.

Subsequent sections present details on the three seminars, and on an orientation to ARS research at the Beltsville Agricultural Research Center.

#### 1. 1984 Tour

In May and June 1984, ten participants visited research facilities at Pullman and Lind, Washington, and Pendleton, Oregon. Both areas have a Mediterranean-like climate with winter rainfall. Research emphases include: conservation

tillage, residue management, soil and water conservation, paired-row planting, and precision fertilizer application to small grain cereal crops, especially winter wheat.

The tour also visited USDA-ARS research facilities at Lubbock and Bushland, Texas, where the change in tillage equipment and soil and water conservation/management practices were of particular interest.

A spinoff of this tour was the development of a simplified no-till drill by the ICARDA participants. The drill combines four separate farmer operations in one pass; it prepares the seedbed, distributes fertilizer, drops the seed, and covers the seed. The result is similar to paired-row planting with larger scale, and more extensive no-till drills. ICARDA has also implemented new studies on tillage systems as a result of this visit to ARS facilities.

2. 1985 Tour

In August 1985, 35 participants traveled by chartered bus to ARD research facilities in Mandan, North Dakota; Sydney and Miles City, Montana; Gilette, Wyoming; Scottsbluff, Nebraska; Akron, Colorado; Garden City, Kansas; Woodward, Oklahoma; Bushland, Texas; Lubbock, Texas; Big Spring, Texas; and Temple, Texas. Participants reviewed research on: soil and water conservation; reduced tillage systems; crop residue management; wind and water erosion control; cropping systems; soil fertility requirements; weed and insect control; and system modeling.

Participants included agricultural scientists and administrators from India, Jordan, Morocco, Burkina Faso, Senegal, Niger, Mali, Sudan, and Kenya, and from several IARCs, FAO and the World Bank. In the Southern Great Plains, the tour group was able to see the current transition of irrigated crop production systems back to one of dryland fallow. This transition is widespread in the Texas High Plains and is dictated by the high input costs needed for irrigated production systems and the low prices received by farmers for basic commodity crops.

3. 1986 Tour

The 1986 tour was organized at the request of the World Bank. The Bank wanted an in-depth focus on conservation/production systems developed for the agricultural, environmental and climatological conditions of the U.S. Southern Great Plains. Among the 24 participants were 16 program managers and administrators from the World Bank, 2 program officers from USDA-OICD, 3 dryland soil/water scientists from ARS, and 3 program managers from S&T/AGR/USAID.

During the one week tour participants visited: the Southern Great Plains Conservation and Production Research Laboratory at Bushland, Texas; the Wind Erosion and New Crops Research Laboratory at Big Spring, Texas; and the Grassland, Soil and Water Research Laboratory at Temple, Texas. The group also participated in a research field day at the Texas A&M University Agricultural Research and Extension Center at Lubbock, Texas, where they observed plot demonstrations on the latest research developments in soil, water and crop management practices.

B. Orientation to ARS Research

In September 1986, TSMM and the Beltsville Agricultural Research Center co-sponsored a one-day orientation of ARS research programs at Beltsville, Maryland. Participants included approximately 40 program managers from the World Bank and 6 from USAID/Washington. ARS scientists gave presentations and fielded questions on a number of relevant research topics.

This orientation opened lines of communication and cooperation and provided valuable insights into ARS research programs, their quality, scope and impact. As both current and potential users of ARS research methods and technologies, participants were enthusiastic about the program. ARS scientists had a unique opportunity to interact and exchange ideas with program managers. Much of the research discussed was highly relevant to many soil, water, crop and livestock management problems in developing countries.

## VII. Conclusions and Recommendations

This progress report summarizes the activities and achievements of TSMM during the past three years. Working primarily in Thailand, Jordan and Mali, TSMM has focused attention on soil and water management problems and initiated research and planning activities to resolve these problems. Annex E lists the various publications, reports and papers which have resulted from the TSMM project as well as printed materials that have been widely distributed.

TSMM has stimulated communication and cooperation among scientists who are working on soil and water management issues and has enhanced the awareness of U.S. expertise in dryland technologies among developing country scientists and among project managers and staff of such international development agencies as the World Bank, FAO, Winrock International, IDRC and the IARCs. Further cooperation and collaboration should contribute to more effective dryland development.

TSMM is unique in that it integrates both the agronomic and economic components. Both components must be addressed if we are to develop more productive, stable and sustainable agricultural systems in semiarid regions. To assess options for dryland development, planners must be able to evaluate the effectiveness of applying new technologies and the economic implications of their use. TSMM's data on the economic aspects of improving dryland agriculture will be relevant to a number of countries in the Sudano-Sahelian zone of Africa.

The following recommendations emerge from TSMM experience.

- TSMM should continue to collaborate with other donors to avoid duplication of effort and ensure cost-effective and meaningful development of rainfed agriculture.

- TSMM should continue to assist in the development of research data bases and workshops within specific countries and to use these activities to build functioning regional research networks in soil and water management.

- TSMM should continue economic analyses to increase understanding of the economic implications of adoption and diffusion of new and improved soil and water management practices.

- TSMM should continue to advise donor organizations and USAID missions on the need for investing time and resources in developing more productive soil and water management systems for rainfed agriculture.

ANNEX A

# CONCLUSIONS AND RECOMMENDATIONS OF WORKING GROUPS, TSMM-SPONSORED WORKSHOP ON "SOIL, WATER AND CROP MANAGEMENT SYSTEMS FOR RAINFED AGRICULTURE IN NORTHEAST THAILAND," FEBRUARY 25-MARCH 1, 1985

## GROUP I: Soil-Water Relationships

### A. Introduction

Agriculture in Northeast Thailand is characterized by an emphasis on rainfed rice production for subsistence. Rice is grown on all lowland areas and on as much of the middle and upper terraces as rainfall permits. The extent to which middle and upper terrace lands are transplanted to rice varies greatly from year to year because rainfall is erratic. Therefore, soil-water research efforts in support of rice production should emphasize how to maintain water saturation and flooding for the time between rains. This work should concentrate on lowland and middle terrace land.

Field crops produced for cash have secondary emphasis. These crops are grown primarily on uplands, but many development projects have shown how to increase land-use intensity by producing these crops in the lowland paddy as pre- or post-rice crops. To assist in growing field crops on uplands, soil-water research should emphasize increasing retention and storage of available water in the soil. This will require attention to infiltration and water holding capacity and efforts to avoid prolonged soil saturation after periods of heavy rainfall.

For field crops grown as pre-rice crops in the paddy, research should emphasize ways to manage the soil to maximize soil saturation and flooding for subsequent rice production, while ensuring that the pre-rice crop obtains sufficient water without losing stands or having adverse effects from soil-waterlogging.

### B. Objectives

(1) To obtain a better understanding of soil and water relationships in major soils of Northeast Thailand.

(2) To develop management techniques to increase the retention and storage of plant available water in major soils of the Northeast region.

C. Research Priorities

(1) Soil-water retention and storage

(2) Conservation tillage

(3) Increased infiltration of water into soil

(4) Decreased evaporative loss of water

(5) Recharge/leaching

(6) Water balance

D. Recommendations for Research and Collaboration

(1) To conduct studies on hydraulic properties of soils both in the laboratory and field, including water-holding capacities, infiltration, percolation, water extraction patterns, depth of water table, evaporation, and actual water storage.

(2) To establish relationships between soil conditions and soil hydraulic properties, both in the laboratory and the field under different management regimes.

(3) To conduct studies on effects of tillage (methods, degree or intensity, and time), surface mulches, composts, crop residues, animal manures and other organic wastes on soil hydraulic properties and other physical properties, infiltration, water retention and storage, and the growth and yield of crops.

(4) To establish water balances for major soils and crops under different management systems and for both lowland and upland terraces.

(5) To conduct adaptable on-farm trials and demonstrations of promising new soil-water conservation techniques.

(6) To encourage the Department of Agriculture (DOA) and the Department of Land Development (DLD), and Universities to engage in collaborative efforts to increase the stability, efficiency, and productivity of farmer's cropping systems in the Northeast region.

E. Recommendations for Education and Training

(1) To provide support to researchers for study, training, educational tours, and for attending technical conferences to be better informed of research being conducted at other locations within the nation, region, and world.

(2) To encourage DOA, DLD, and Universities to engage in on-farm adaptive research and demonstrations.

F. Recommendations for Networking

(1) To identify researchers working in areas of soil-water relationships for rainfed agriculture in Thailand, the Southeast Asia region, and the world.

(2) To provide mechanisms for exchanging information on research results, methods, and techniques, and for establishing research priorities.

## Group II: Agroclimatology and Cropping Systems

A. Introduction

The erratic rainfall patterns and poor soils have placed tremendous constraints on the farmers of Northeast Thailand. Over the centuries, farmers have evolved various strategies to cope with these constraints. Some cropping patterns appear to use residual moisture efficiently or to utilize water from the water table. However, these practices are not widespread throughout the region.

The challenge remains for research and extension to study the rainfall and soil moisture characteristics and the existing farming practices at locations where there is presently efficient use of available technology and where transfer of technology might be feasible. An integrated approach, involving all aspects of soil, water, fertility and management, is essential.

Research and extension programs that facilitate the technology transfer and dissemination process need to be developed.

Improvements in cropping patterns that maximize stability as well as productivity are needed. These improvements will require the efficient utilization of available water resources, including rainfall, soil moisture, water table, shallow wells, ponds and tanks.

B. Objectives

(1) To review existing research data bases concerning agroclimatology and cropping systems in Northeast Thailand; and

(2) To identify research priorities for developing new technologies to use water resources more efficiently.

C. Research Priorities and Recommendations

(1) To determine crop water requirements under existing soil and water management systems and with improved systems. Develop or utilize models to characterize relationships between variables involving the soil, water atmosphere (climate) and plant.

(2) To define soil, water and plant relationships based on agro-ecological zoning.

(3) To develop crop management systems and strategies in relation to agro-ecological zoning including careful consideration of agroclimatic factors, improved crop calendars, and crop sequencing for more efficient utilization of stored water.

(4) To conduct studies for on-farm verification of agroclimatic models and crop models that would lead to the development of more stable, efficient and productive farming systems.

(5) To foster regular meetings between university and government personnel who are working on agroclimatic models and farming systems, and extension specialists, so that advisory materials can be prepared for use by farmers.

## Group III: Soil and Water Management

A. Introduction

The inherent fertility of most major Northeast soils was depleted long ago, or exhausted from long-term cropping without sufficient replacement of plant nutrients and long-term soil erosion, nutrient runoff loss, and organic matter depletion. Consequently, the tilth, fertility, and productivity of Northeast soils are low.

Probably the best means of restoring the fertility and productivity of these soils is through the effective and efficient use of traditional agricultural organic materials (crop residues, animal manures, green manures, and composts). These should be used in proper combination with judicious amounts of chemical fertilizers. The use of organic amendments should enhance the crop-plant use-efficiency of chemical fertilizers, and result in a substantial reduction of fertilizer costs. Organic materials also improve soil physical properties, such as increased soil aggregation, water-holding

capacity and permeability, and decreased bulk density, surface crusting, and compaction. All of these can improve the productivity of the Northeast soils substantially.

B. Objective

To identify and characterize soil fertility problems and propose countermeasures to alleviate such problems by proper utilization of organic wastes and residues, chemical fertilizers, and soil amendments.

C. Research Priorities

(1) Research to increase the organic matter content in major Northeast soils.

(2) Research on soil fertility evaluation and efficient use of fertilizer.

(3) Research on soil acidity and salinity problems to overcome constraints to efficient and productive agriculture in the Northeast.

D. Major Recommendations

(1) To conduct surveys (on-farm) of how farmers are utilizing organic wastes/residues on land.

(2) To conduct basic research on organic matter decomposition in major Northeast soils and those factors affecting decomposition.

(3) To conduct basic research on compost process technology for different organic materials including on-farm wastes, municipal wastes, and industrial wastes.

(4) To investigate the best selections of green manure crops that can be adapted to specific cropping systems in the Northeast.

(5) To conduct basic research and on-farm research on the amount of various types of crop residues needed to maintain tilth and productivity of problem soils, for example, those affected by excess salinity.

(6) To conduct basic research and on-farm research on the effect of organic matter additions (rate/mode/time of application) on alleviating soil salinity in Northeast soils. Short-term and long-term studies are needed.

(7) To determine the practical and workable balance between organic fertilizer sources and chemical fertilizers that would provide sufficient levels of plant nutrients to specific crops grown in a particular system or sequence.

(8) To determine the use-efficiency by crops of plant nutrients contained in chemical fertilizers when they are applied to soil, with and without organic residues and amendments.

E. Other Recommendations

(9) To evaluate and assess the lime requirement of crops and the effect of lime on plant growth and yield.

(10) To determine the CEC at native soil pH for estimating percent base saturation.

(11) To establish N-response curves for crops to determine the critical crop requirement for P and K, and soil test procedures for better correlation with P and K.

(12) To determine the nitrogen contribution of legumes in cropping systems.

(13) To determine the extent of fixation and release of P and K in cropping systems as affected by soil properties and water management practices.

(14) To assess and evaluate the crop requirement for micronutrients and secondary nutrients in Northeast soils. Deficiencies of these nutrients should be expected as good management practices increase the crop yield potential.

ANNEX B

# SUMMARY OF DATA BASE FINDINGS ON SOIL/WATER/CROP MANAGEMENT FOR RAINFED AGRICULTURE IN JORDAN

## Summary of Findings

### A. Governmental Policies

The Government of Jordan has now recognized the necessity and importance of directing more effort toward the improvement of the rainfed sector. The government subsidizes farmers by importing duty-free agricultural supplies, through the private sector, and by purchasing wheat from farmers at a higher than market price. However, farmers are not benefitting substantially from this policy. High production inputs are a major factor prohibiting farmers from adopting modern crop production techniques. Farmers could be encouraged to invest more in rainfed agriculture if government subsidies were directed towards machinery, fertilizers, and herbicides.

### B. Soil Resources and Soil Conservation

Soil resources are very limited and population pressure on them is increasing. Only 25 percent of the rainfed area has been surveyed, but a land capability classification was completed for the whole country. Natural and man-made erosion are causing the loss of fertile lands and/or reducing their productivity. Quantitative data is lacking on the extent of erosion. However, a number of erosion control projects have been carried out in the country. Research and modeling are urgently needed.

### C. Agroclimatology

Rainfall is the most important and the most variable of the physical factors affecting rainfed crop production. Although many records have been compiled over the last 50 years, the number of studies on agricultural meteorology is very limited. High-speed computers will facilitate the systematic use of climatological information. Using computers, data can be used to construct or modify simulation models for crop growth, development and production.

### D. Cultural Practices

Cultural practices have been developed on the basis that soil moisture is the main factor limiting production. Recommendations have been developed for planting dates, rates,

depths, and planting methods for major field crops. However, research on minimum tillage, response farming and seasonal forecasts of rainfall probability is needed to determine the best type and timing of certain key cultural practices.

E. Crop Rotation

Research on crop rotation has been limited. Traditional rotation includes a fallow year. Recently, there appears to be a trend to replace fallow with forage and/or grain legumes.

Other chapters in the data base cover soil fertility, soil-water relations, weed control and modeling.

ANNEX C

DESCRIPTION OF "RIBBON PROJECT"
to be implemented in Near East Region, 1987

Project Title: A study of alternative residue and tillage practices on production efficiency of rainfed crop-livestock systems in the Near East Region.

A. Background

Most of the rainfed cereal-growing areas (wheat and barley) in the Near East Region have a Mediterranean semiarid climate with precipitation averaging between 200 and 500 mm annually. The rainfall is often distributed during a short rainy season in unpredictable amounts and frequently occurs as intensive storms that can severely erode the land. Livestock are also produced on the drylands and are a significant component of agricultural production.

A common practice throughout most of the dryland areas is intensive utilization of crop residues during the fallow period by grazing sheep (and sometimes goats, cattle and camels). Weeds are usually allowed to grow to supply additional forage. The intensive grazing practice with animal trampling leaves the soil surface bare and compacted during much of the fallow period, and highly vulnerable to wind and water erosion. The removal of stubble and weedy fallow is also costly in terms of water loss through increased runoff and evapotranspiration, particularly during the rainy season. With less available water, subsequent crop yields are smaller.

Wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*) are the main cereal crops in most dryfarming systems in the Near East Region. Wheat is generally grown in the medium and higher rainfall areas, and barley in the dryer areas. In addition to these crops, farmers also produce pulses including lentils (*Lens culinaris*), faba bean (*Vicia faba*), and chickpeas (*Cicer arietinum*), vegetables, and in some cases, annual legumes such as vetches (*Vicia* sp.) in rotation with winter wheat.

With the livestock grazing system, wheat and barley yields generally range from 200 to 1000+ kg/ha in the different rainfall zones. Residue amounts associated with these grain yields would be in the order of 300 to 1500+ kg/ha. At this level of dryland production, essentially all of the crop residue would be required during the rainy season for effective water conservation and erosion control.

Demonstrations in Turkey and Syria show that yields with present farming systems can be increased by application of improved technology (for example, improved tillage and fertilizer practices and crop varieties). However, in most situations substantial improvements in yields can come about only by increasing the supply of available water in the soil. This means that at least a portion of the residue from cereal crops will have to be returned to the land using the best management practices (residues concentrated mainly at or near the soil surface). Also, until a higher yield is reached, which would produce more residue, there may be a shortage of residues for ruminant animals.

B. The Study

This study is designed to obtain data on the agronomic, economic and resource efficiency of traditional and alternative farming systems. Alternatives include controlled grazing or no grazing, with or without weed control. Also, a set of tillage treatments will be imposed as an additional variable, to study the effects on water conservation. Grazing treatments are simulations with the animal product determined by chemical analysis of harvested residues and weeds.

The data from the field experiment are intended to provide parameters for a modeling study, to expand the range of variables and permit extrapolation from the experimental site to other climatic and soil conditions.

This study will require the collaborative effort of the following disciplines: agronomy, social sciences, animal nutrition, and agricultural economics. Modeling expertise, if not available locally, can be acquired through USAID.

The experiment should be run for a minimum of five years on the same plot site. Two blocks of land are needed so that simulated grazing/fallow and wheat components can be carried out each year. The blocks of land should be close to each other. The treatments and other details of the experimental approach may vary slightly from country to country. Flexibility is allowed to permit changes during the course of the experiment. Project leaders and associated personnel should be encouraged to meet once a year to compare results and discuss any changes thay may be needed in the experimental plan. Annual reports summarizing results for each of the projects should be exchanged at this time. A detailed project report will be prepared at the end of the experiment.

ANNEX D

# PROPOSED OUTLINE FOR THE SOIL/WATER CROP MANAGEMENT DATA BASES FOR NIGER, MALI AND SRI LANKA

## I. Background Data

### A. Soil Resources

1. Soil taxonomy
2. Soil chemical/physical/organic properties
3. Soil classification/mapping

### B. Agroclimatology

1. Rainfall patterns
2. Climatic patterns
3. Rainfall probability/analysis
4. Potential evaporation (PE)
5. Potential evapotranspiration (PET)
6. Pan-evaporation
7. Relationship of agroclimatology to improved crop calendars

### C. Water Resources Supply

1. Surface supplies (quantity, quality, location, development)
2. Groundwater supplies (quantity, quality, location, development)

### D. Soil-Water Relationships

1. Water storage in soils
2. Runoff and leaching
3. Infiltration
4. Hydrologic balance
5. Water use-efficiency

### E. Crops and Cropping Patterns

1. Crop selection
2. Crop calendars
3. Crop rotations

## II. Soil Management

### A. Soil and Soil Moisture Conservation (wind and water erosion)

1. Conventional tillage practices
2. Soil/moisture control practices
   a. No till, minimum till
   b. Crop residue management
   c. Tied ridges
   d. Dikes
   e. Windbreaks
3. Changes in crop calendars
4. Soil moisture response functions for soil/moisture control
5. Crop yield response functions for soil/moisture control
6. Farm input requirements for soil/moisture control
7. Environmental impacts of soil/moisture control
   a. On-farm
   b. Off-farm

### B. Soil Salinity, Alkalinity, Acidity, Toxicity

1. Methods for improving soil quality
2. Crop yield response to soil quality improvements
3. Input requirements for soil quality improvements

### C. Soil Fertility

1. Fertilizer forms and sources
2. Rate and timing of fertilizer applications
3. Fertilizer placement
4. Legume nitrogen
5. Manures, crop residues, composts
6. Organic matter transformation in soils
7. Soil moisture response functions for fertilizers
8. Crop yield response functions for fertilizers
9. Fertilizer application requirements (farm)
   a. Material
   b. Equipment
   c. Labor
   d. Energy
   e. Equipment maintenance and repair
10. Changes in crop calendars with fertilizers
11. Environmental impacts of fertilizers
    a. On-farm
    b. Off-farm

## III. Water Management

### A. Water Conservation

1. Conventional water supply management practices
   a. On-farm
   b. Off-farm
2. Problems with conventional practices
3. Water conservation measures on-farm
   a. Bench terraces
   b. Water harvesting
4. Changes in crop calendars with water conservation
5. Crop yield response functions for water conservation practices
6. Farm input requirements for water conservation practices
7. Environmental impacts of water conservation practices

### B. Water Quality Control

1. Conventional water quality control practices, i.e. on-farm
2. Problems associated with conventional on-farm practices
3. Water quality control practices
4. Change in crop calendars with water quality control
5. Crop yield response functions for water quality control
6. Farm input requirements for water quality control
7. Environmental impacts of water quality control

## IV. Cropping Systems

### A. Soil-Improving Crops

### B. Fertilization in Cropping Systems

### C. Multiple Cropping and Crop Rotations

### D. Intercropping Systems

### E. Input Requirements for Cropping Systems

### F. Crop Yield Functions for Cropping Systems

### G. Impact of Cropping Systems on Farm Calendars and Operations

## V. Systems Modeling

### A. Physical Systems

1. Soils (soil moisture, infiltration, runoff)
2. Plants
3. Crops (input/output)
4. Livestock
5. Whole farm system

### B. Socioeconomic Systems

1. Crop and livestock production
2. Farm
3. Household
4. Regional/national/policy system

# ANNEX E

## PUBLICATIONS, REPORTS AND PAPERS

### I. Publications Produced Under TSMM

Dregne, H.E. Dryland Soil Resources. Washington, D.C.: Agency for International Development (S&T/AGR/RNR), 1982.

Hargreaves, George H., and Samani, Zohrab A. World Water for Agriculture - Precipitation Management. Logan, Utah: International Irrigation Center, Utah State University, 1986.

Hargreaves, George H. Dependable Precipitation and Potential Yields for Senegal, A Practical Guide for Rainfed Agriculture. Logan, Utan: International Irrigation Center, 1982.

Hargreaves, George H. and Samani, Zohrab A. Rainfed Agriculture in Haiti. Logan, Utah: International Irrigation Center, 1983.

Hargreaves, George H.; Prasad, U.K.; Samani, Z. A.; Patwardhan, M.M.; Pawar, D.H.; and Bhola, A.M. A Crop Water Evaluation Manual for India. Logan, Utah: International Irrigation Center, 1985.

Samani, Zohrab A. and Hargreaves, George H. A Crop Water Evaluation Manual for Brazil. Logan, Utah: International Irrigation Center, 1985.

### Papers, Lectures and Seminars Presented Under TSMM

#### 1984-85

Burnett, E. "Land and Water Management Practices." Presented at IBSRAM workshop on "Management of Vertisols for Improved Agricultural Production," sponsored by ICRISAT and SMSS. Held at ICRISAT Center, Patancheru, India, February 18-22, 1985 (Proceedings in press).

Burnett, E. "Conservation Production Systems for Dryland Agriculture." Presented at a TSMM sponsored workshop on "Soil, Water and Crop Management Systems for Rainfed Agriculture in Northeast Thailand." Held at Khon Kaen, Thailand, February 25-March 1, 1985 (Proceedings in press).

Parr, J. F. and Papendick, R. I. "Soil and Water Conservation Practices in Dryland Farming Areas of the United States." In proceedings of an International Dryland Farming Seminar sponsored by Oregon State University, USAID, and Ecole Superieure d'Agriculture (Le Kef, Tunisia). Held at Kasserine, Tunisia, July 16-19, 1984.

Parr, J.F. and Meyer, R.E. "Strategies for Increasing Soil Productivity in Developing Countries." Presented at TSMM-sponsored workshop on "Soil, Water and Crop Management Systems for Rainfed Agriculture in Northeast Thailand." Held at Khon Kaen, Thailand, February 25-March 1, 1985 (Proceedings in press).

Parr, J.F. "Use of Organic Materials as Fertilizer Sources in Developing Countries." Keynote address at the Annual Meetings of the Canadian Soil Science Society, held at Charlottetown, Prince Edward Island, Canada, June 23-27, 1985.

Parr, J.F. "Development Strategies for Dryland Agriculture; a Focus on Sub-Saharan Africa." Invited lecture presented to the College of Agriculture, University of Illinois, Champaign-Urbana, November 21, 1985.

Somapala, H. "An Overview of Land and Water Conservation and Management Under Rainfed Agriculture in Sri Lanka." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop Management Systems for Rainfed Agriculture in Northeast Thailand." Held at Khon Kaen, Thailand, February 25-March 1, 1985 (Proceedings in press).

Stewart, B.A. "Dryland and Irrigated Use of Vertisols." Presented at a IBSRAM workshop on "Management of Vertisols for Improved Agricultural Production," sponsored by ICRISAT and SMSS. Held at ICRISAT Center, Patancheru, India, February 18-22, 1985 (Proceedings in press).

Stewart, B.A. and Skidmore, E.L. "Water Requirements of Crops." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop Management Systems for Rainfed Agriculture in Northeast Thailand." Held at Khon Kaen, Thailand, February 25-March 1, 1985 (Proceedings in press).

Unger, P.W. "Conservation Effective Tillage." Presented at a IBSRAM workshop on "Management of Vertisols for Improved Agricultural Production," sponsored by ICRISAT and SMSS. Held at ICRISAT Center, Patancheru, India, February 18-22, 1985 (Proceedings in press).

Unger, P.W. and Steiner, J.L. "Methods of Characterizing Soil-Water Relationships." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop Management Systems for Rainfed Agriculture in Northeast Thailand." Held at Khon Kaen, Thailand, February 25-March 1, 1985 (Proceedings in press).

Vankateswarlu, J. "Soil, Water and Crop Management in Rainfed Agriculture: The Indian Experience." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop Management Systems for Rainfed Agriculture in Northeast Thailand." Held in Khon Kaen, Thailand, February 25-March 1, 1985 (Proceedings in press).

1986

Al-Ahmad, M.J. "Land Management, Crop Rotations and the Effect of Weeds on Soil Moisture and Crop Production in the Near East Region." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Colacicco, D. and Barbarika, A. "Economic Analysis of Soil and Water Conservation Practices." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Durutan, N.; Pala, M.; Karaca, M.; and Yesilsoy, M.S. "Soil Management, Water Conservation and Crop Production in the Dryland Regions of Turkey." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Fenster, C. R. "Effect of Weed Control Practices on Soil Water Conservation in the Near East." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Fryrear, D. W. "Mechanics of Wind Erosion: Measurement, Prediction and Control." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Gregory, P.J. "Crop Water Use Efficiency." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Izumi, Takaaki. "Concepts of Systematic Commodity.Resource Analysis and Development Process as Applied to Rainfed Agricultural Development Projects, and Regional Soil Water Management Programs." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Jaradat, A.A. "Data Acquisition and Processing Techniques for Agricultural Research." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Khan, A. R.; Qayyum, A.; and Choudhary, G. H. "Soil, Water and Crop Management Systems for Dryland Agriculture in Pakistan." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

McCool, D.K. "Mechanics of Water Erosion: Measurement, Prediction and Control." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Moustafa, A. T. A. "Soil, Water and Crop Management Systems for Dryland Agriculture In Egypt." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Mulla, D.J. "Soil Spatial Variability and Methods of Analysis." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Mulla, D.J. "Measurement and Characterization of Soil-Water Relationships." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Osman, A. "Soil Resources of the Arab Countries in the Near East Region." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Papendick, R.I. "Storage and Retention of Soil Water During Fallow Periods." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Papendick, R.I. and Parr, J.F. Co-editors of "Tillage Practices for Low Rainfall Areas." To be published by the Food and Agriculture Organization (FAO), Rome.

Parr, J.F. "Utilization of Organic Wastes for Increased Agricultural Productivity in Developing Countries." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Parr, J.F. "Utilization of Organic Wastes and Residues To Increase Soil Productivity." Invited lecture presented to the College of Agriculture, Clemson University, Clemson, South Carolina, April 14, 1986.

Parr, J.F. and Meyer, R.E. "Strategies for Improving Soil and Water Management Research and Networking in Semiarid Regions." Presented at "The International Food Legume Research Conference on Pea, Lentil, Faba Bean and Chickpea." Held in Spokane, Washington, July 6-11, 1986 (Proceedings in review).

Parr, J.F. "Utilization of Urban Wastes for Soil Conservation/ Production Systems in Developing Countries." Lecture presented to the World Bank and USAID Program Managers, Beltsville, Maryland, September 2, 1986.

Parr, J.F.; Papendick, R.I.; and Colacicco, D. "Recycling of Organic Wastes for a Sustainable Agriculture." Biol. Agric. Hort. 3:115-130.

Stewart, J.I. "Response Farming for Improvement of Rainfed Crop Production in Jordan." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

Stewart, J.I. "Mediterranean-type Climate, Wheat Production and Response Farming." Presented at a TSMM-sponsored workshop on "Soil, Water and Crop/Livestock Management Systems for Rainfed Agriculture in the Near East Region." Held in Amman, Jordan, January 18-23, 1986 (Proceedings in review).

## Printed Materials Distributed by TSMM

### Books

Various authors. "Conservation Tillage." Special issue of Journal of Soil and Water Conservation 38(3) May-June 1983.

Dregne, H.E. and Willis, W.D. Dryland Agriculture. Agronomy Monographs #10. Madison, Wisconsin: American Society of Agronomy, 1983.

Hopkins, S.T. and Jones, D.E. Research Guide to the Arid Lands of the World. Oryx Press, 1983.

### Papers

Onstad, C.A. "Current Research Topics in Soil Erosion Processes." Soil conservation workshop, Thailand, Nov. 9-21, 1984.

Onstad, C.A. "Problems and Constraints of Soil Conservation in the U.S.A." Soil conservation workshop, Thailand, Nov. 9-21, 1984.

Swindale, L.D. "Distribution and Use of Arable Soils in the Semi-Arid Tropics." Presented to a session on Managing Soil Resources, Plenary session papers - 12th International Congress of Soil Science, New Delhi, Feb. 8-16, 1982.

☆U.S. Government Printing Office : 1987 -180-917/60116