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**MOISTURE UTILIZATION IN SEMI-ARID TROPICS**  
**(Summer Rainfall Agriculture)**

**FINAL TECHNICAL REPORT NO. 5**

**1978 - 1979**

**Grant No. AID/ta - G -1141**

**University of California**  
**Riverside, California**

**211(d) Final Report**

**Date Due: July 1, 1980**

**Date: July 18, 1980**

**Grant Title: MOISTURE UTILIZATION IN SEMI-ARID TROPICS:  
Summer Rainfall Agriculture**

**Grantee: University of California, Riverside**

**Grant Program Director: Dr. Glen H. Cannell**

**AID Sponsoring Technical Office: Technical Assistance Bureau/Agriculture**

**Statistical Summary:**

**Period of Grant: June 20, 1974 to December 31, 1979**

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## I. NARRATIVE SUMMARY

### A. Accomplishments

#### 1. Reporting Year

In this final year of the grant the computerized bibliographic information data base has been expanded to more than 13,500 entries, and about 1,000 additional entries are being processed. The information network (CIDNET), established in cooperation with the Consortium for International Development (CID), and with the reference center located at Riverside, is now completely computerized. The bibliographic data base has 32,000 entries and is searchable. The areas of interest cover a broad spectrum of soil-water management in crop production, such as: crop production in semi-arid regions, on-farm soil water management, water delivery systems to and from the farm, small watershed management, and many items on development and planning in various developing countries.

Some copies of the "Proceedings of an International Symposium on Rainfed Agriculture in Semi-arid Regions, 1977" are still available. Copies can be obtained from the following address: CIDNET Information Center, Soil & Environmental Sciences, University of California, Riverside, CA 92521. "Agricultural Research in Semi-arid Regions: a Resource Directory", was completed and published in early 1979 by G.K. Hall & Co., 70 Lincoln Street, Boston, Mass 02111. The "State of the Art: Acacia albida as a Complementary Permanent Intercrop with Annual Crops", 1978; a few copies are still available (use address given above). The State of the Art: "Agriculture in Semi-arid Environments" (Ecological Studies 34) was published in 1979 by Springer-Verlag, Berlin.

#### 2. Life of Grant

Accumulative accomplishments of the grant are summarized as follows:

1) The Centralized Information Center developed under the grant using a computerized bibliographic information base and is one of excellence. Although grant funds for the Center have expired, plans are to seek other funds to continue the Center under the title of CIDNET Information Center. The addition of CIDNET has broadened the data base and makes the Center more diversified and user-oriented on a local, national and international basis. The data base is particularly useful in the areas of soil-water management covering both irrigated and dryland agriculture. All the CID universities are strongly involved in research in these two areas. 2) Grant field research projects on cowpeas covering N-fixation, soil physical properties and root development, breeding for drought resistance, soil-water balance, modelling studies, nematode research in semi-arid soils, and soil-water management on crop production. Information gained on these field projects is being utilized through publications and expertise developed from these projects is being applied under Title XII Cowpea/Bean Cooperative Research Support Program and other international assistance programs. Fifteen major publications were developed during the life of the grant: 1) Central Information System, 2 books; 2) Symposium, 1 book; 3) State of the Art, 2 books; 4) Journal and equivalent publications, 11 articles. In addition, 8 theses, 5 Ph.D. (two of these to be completed in 1980) and 3 M.Sc. Various other publications as journal articles will follow from the theses. More than 30 faculty and staff actively participated in project activities and about half of these gained experience on overseas assignments.

## II. DETAILED REPORT

### A. General Background and Description of Problem

Life requires food, and the production of food depends upon the understanding of the effects of weather, soil, and man/plant/animal relationships. The interrelationships of these factors allow us to develop reliable plans for the development of food production techniques as they affect land use. This needs to be accomplished without damage or loss of natural resources. Agencies of the United Nations, governments of developed nations, private foundations, and research institutes have done much to improve food production and alleviate hunger. Among significant breakthroughs were hybrid corn in the 1930's; grain sorghum, pearl millet and hybrid monogerm sugar beets in the 1950's; and the Green Revolution, which introduced new wheat and rice varieties in the 1970's. Yet all of these achievements have constituted only a few small steps in the fight against hunger.

At present almost 85 per cent of the cultivated lands of the world depend entirely upon precipitation to supply soil moisture for plant growth. The Sahelian and Sudanian zones of Africa, where acute drought conditions resulted in great human suffering the early 1970's, have refocused attention on the urgent need for developing new programs to make underdeveloped or marginal lands productive and to reclaim deteriorating grasslands.

The potential for increasing crop production and restoring grasslands in these regions of Africa, and solving similar problems in many other semi-arid areas of the world, involves the essential component of water management. Although considerable attention has been given to development of crop varieties and agricultural practices under adequate moisture conditions, research leading to the development of an arid-farming technology for the developing countries has been virtually non-existent. Principles and practices developed for dryland agriculture in the United States cannot simply be transported to other regions of the developing world, for many reasons. If farming productivity in these regions is to be increased, it will be necessary to employ integrated systems approaches to developing crop manage-

ment practices for specific crops, soils, and climatic conditions. Such practices must make efficient use of available resources (such as precipitation, fertilizers, levels of mechanization, etc.) and they must be economically and culturally feasible for application in the developing countries.

Given this perception of the problem and the direction for approaches to a solution, the University of California, Riverside was able to measure its ability to work toward that solution. UCR, through its Citrus Research Center and Agricultural Experiment Station, has been continuously involved since 1967 in problems related to research and management of agriculture in arid and semi-arid lands. The Agricultural Experiment Station has as one primary mission the development of knowledge of plants of importance to agriculture in semi-arid tropical climates. This mission relates primarily to agricultural production in semi-arid Southern California, but the AES has acquired an international reputation in sub-tropical horticulture and semi-arid land crop production that goes back to the early 1920's. Members of its research staff are involved in many international organizations relating to agriculture and have frequently served as consultants in many foreign lands.

It was evident, therefore, that UCR already had strength in this area, and could increase that strength with the support of the grant. Other aspects of UCR's present strength and capacity for growth include:

(1) Instructional Resources: UCR, with its various divisions and colleges, offers a solid core of academic courses, and degrees in fifty-six majors. Of particular strength is the College of Natural and Agricultural Sciences. One hundred twenty-seven staff members of the Agricultural Experiment Station hold appointments with the College of Natural and Agricultural Sciences and thus share their expertise in crop production, soil-water problems, pest management, plant disease protection, pollution problems, and other research areas related to semi-arid ecosystems. UCR already offers a variety of multi-disciplinary degree programs, setting a valuable precedent for new programs of this type which would deal more specifically with grant-related topics.

To complement and enlarge its present instructional resources under the 211(d) grant, UCR proposes to: (1) increase the graduate program and add an international dimension in dryland farming; efforts would be made to increase the number of students from developing countries in the field of dryland farming; (2) initiate Outreach Training Programs, short-term courses designed for developing country personnel; (3) institute special non-degree programs designed to train groups for work in semi-arid tropical regions of the developing countries.

(2) Research Resources: Staff members are encouraged to devote research efforts to grant-related projects. In the course of the State of the Art review, specific problem areas have been identified and research projects undertaken. These research projects include dissertation research by graduate students as well as staff research.

(3) Informational Resources: The UCR Library has a collection of over one million volumes in open stack arrangement. One of its specialized branches is the Bio-Agricultural Library, which contains an outstanding collection of more than 86,000 books related to agriculture, sub-tropical horticulture and the biological sciences. It currently receives some two thousand fifty-five serial publications. Through contracts with commercial purveyors of bibliographic data bases (Lockheed and Systems Development Corporation) the UCR Library offers computer literature searches on a number of data bases, including CAIN, NTIS, and BIOSIS. Under the grant the UCR Library is enlarging its collection in the topics of agriculture in the semi-arid tropical regions, geographic, social and economic works on the Sahel area of West Africa, and all material related to grant problems. This collection is recorded on a computerized data base that provides quick and easy access to any of the material through indexes of title, author, source, subject and geographic areas.

(4) Consulting Services: Already experienced in consultation services, the staff of the Agricultural Experiment Station and of the College of Natural and Agricultural Sciences is increasing its expertise in problems of the semi-arid tropics to provide a core of personnel available for advisory tasks for the developing countries.

## B. Purpose of the Grant

The grant is being used by UCR to develop an institutional response capability to deal with dryland moisture conservation, utilization and farming problems in arid and semi-arid tropical regions in developing countries with summer rainfall. This capability requires building a core of experienced faculty with expertise in advising and training, knowledge of the research field, and the ability to implement adaptive research or training programs in the developing countries, and contribute to upgrading their capabilities for improved crop production and moisture utilization through integrated crop-management systems. As an outgrowth of this program UCR can be expected to become a center of U.S. competence in dryland farming for semi-arid tropical regions.

## C. Objectives of the Grant

1. Objectives Restated - The proposed program will strengthen the competence of UCR in selected areas of knowledge and improve its communications with appropriate institutions here and abroad so that an institutional response capability can be achieved in dryland farming in arid and semi-arid tropical regions. The three primary thrusts in strengthening UCR's competence will be as follows:

(1) Improvement of UCR's understanding of the current status of present and proposed practices in moisture conservation and utilization in dryland farming and their applicability to developing countries in semi-arid tropical regions. This will include an improved understanding of dryland farming systems and environmental conditions in the developing countries.

(2) Development of mechanisms which make possible effective interdisciplinary research, advisory and Extension capabilities relating to dryland farming.

(3) Improvement of educational capabilities at UCR for students and staff to acquire greater knowledge of the principles and practices of dryland farming throughout the world.

The time sequence of activities related to the grant objectives is moving at a rate compatible with the output. Emphasis has been placed on involving French researchers from the Sahel in the State of the Art report and other project activities.

2. Review of Critical Assumptions - Assumptions were made that will have a negative impact on the productivity of the program if they should prove to be incorrect. The assumptions are as follows:

Assumption No. 1. It is assumed that AID/W will provide assistance in the initiation of linkages with the developing countries, in identifying training needs of institutions and individuals and sites for cooperative activity in the developing countries, and in the exchange of information as part of the linkage network.

Assumption No. 2. It is assumed that U.S. and developing country institutions will cooperate with UCR in regard to the initiation and strengthening of linkages, exchanges, and visits by staff and students, information exchange, and other cooperative activities.

Assumption No. 3. It is assumed increasing numbers of students, both from the U.S. and the developing countries, will be interested in graduate programs at UCR and the educational offerings that are relevant to dryland agriculture in low rainfall regions of the world.

### III. ACCOMPLISHMENTS

#### General or Introductory Statement

The team concept selected as a means of developing an interdisciplinary relationship among faculty involved in the program has proven successful in achieving each objective/output in the grant program. Effectively used in agricultural research, this method has adapted well to use in the project, and the teams that were selected during the first two weeks of the program have remained stable except for a few changes or additions in personnel. Guideline materials were also developed in the early stages of the project and have been revised as progress has been made. The teams remain as identified in the previous report and have been revised as progress has been made. The teams remain as identified in the previous report and have been active in developing programs to satisfy each objective/output in a sequence to meet the timetable of the grant. The team responsibilities are as follows:

- |                                                       |                        |
|-------------------------------------------------------|------------------------|
| 1. Information Resources Team                         | Objective/Output 1 & 2 |
| 2. Research Team                                      | Objective/Output 3     |
| 3. Educational Training & Advisory                    | Objective/Output 4     |
| 4. Curriculum & Development Team                      | Objective/Output 5     |
| A. Objective/Output No. 1: Central Information System |                        |

1. Narrative Description - The Information Resources Team identified two major targets for the term of the grant within this desired objective/output: (1) to provide project team members with the information needed for them to prepare a State of the Art report

and to embark on the cooperative research projects which will constitute their work in the overall project; and (2) to establish at UCR an Information Center on agriculture in the semi-arid tropics. This latter target would make existing information, as well as the results of the project research, accessible to interested researchers and other groups the world over.

A major undertaking in establishing this Information Center was the preparation of a computerized bibliographic data base using TRIM (Technique for Report Index Management), a program developed specifically for the organization of small special collections by Everett Wallace, Associate University Librarian at UCR former (retired) head of the Library's Systems Department. This data base is now comprised of 13,500 items, including journal articles, monographs, reports, and reprints from a wide variety of sources. Procedures were initiated and tested with the acquisitions and cataloging departments of the UCR Libraries for integrated efforts in building the collection according to the grant objectives. Liaison with the Serials and Monographs departments of the Library have been effected and, since the grant involves interdisciplinary research, cooperation was sought and received from the diverse branches of the University Libraries. Gladys Murphy, Head of Library Acquisitions, has proved exceptionally resourceful in developing procedures for locating and purchasing material from sources ranging from U.S. distributors to remote research stations in West Africa.

Use of the bibliographic resources and collection have increased during the reporting year as awareness of project services continued to grow. Due to increased information demands from national and international

requestors it was determined that microfiche copies of the data base would be most cost-effective. As a result microfiche readers have been purchased for use by the Information Center, students, faculty and visitors.

Intensive information-support was provided for the completion of the State of the Art papers. Publication of the Resource Directory for Agricultural Research in Semi-Arid Regions was accomplished in this reporting year by G. K. Hall. Increased project staff needs were identified and supported and new areas of collection-building have been developed to support the scope of the State of the Art and the initiation of expanded research projects. In anticipation of the end of the project, comprehensive discussions, plans and proposals were developed to maintain and continue the Information Center services beyond the project limitations.

2. Targets for the Reporting Year - To continue the development of MUSAT's information services by:

(a) Selection of current and retrospective material from bibliographies, publication lists, commercial data bases, recommendations of research staff and input from other research organizations, and to obtain copies of these items for the UCR Libraries collection, or for the Information Center collection.

(b) Review and revision of collection development guidelines.

(c) Establishment of working relationships with publishers, dealers, documentation centers, research centers, etc. to facilitate not only the acquisition of material, but also the development of cooperative linkages.

- (d) Continued evaluation of input procedures to the TRIM system and revision of the subject thesaurus.
- (e) Awareness and collection of new additional or revised data for potential supplements to the Resource Directory publication.
- (f) Provision of reference assistance and other research aids to Project members, graduate students, and other persons using the data base and collection.
- (g) Provision of reference assistance in response to requests from outside the University, especially those from developing countries.
- (h) Introduction and training in use of microfiche and microfiche readers. Awareness of the latest techniques and innovations in the equipment and services field.
- (i) Background research, discussion and development of plan of action and proposal considerations for continued operation of information center operation and services beyond the end of the grant.
- (j) Preparation of a comprehensive and unique 3 yr. proposal utilizing international document delivery through microfiche production to disseminate data base resources.
- (k) Continued coordination with UCR Libraries development plans and objectives.
- (l) Revision and refinement of centralization plans for the operation of CIDNET services and Information Center.
- (m) Planning and implementation of alternate strategies for possible hiatus and temporary suspension of operations. Refinement of center operations and connections to a maintenance level without a significant break in services.

The magnitude of progress toward these targets depends largely on the nature of the targets themselves. Target (a) is of course a continuing activity. The bulk of retrospective acquisitions was planned for the first two calendar years of the grant, after which the budget allocation for purchase of books and other library materials drops to a level compatible with continued acquisition of newly published materials and selected retrospective material. Current materials are given priority to keep pace with new developments in the research field and to provide information support for expanded or newly established research projects by faculty and related graduate students.

The computer profile for ASCA (Automatic Subject Citation Alert) and other data bases as appropriate has been reviewed and revised, along with the African Inprint Library Services approval service. Anticipating the project completion items for purchase were prioritized.

Targets (b) and (c) are in response to the stabilization of acquisitions procedures and a need for refinement. Notifications were made to the phase-down of activities and provisions set for temporary suspensions. Target (d) is also a continuing project. The initial adjustment of the TRIM format for the MUSAT:era Information Center was accomplished during the first reporting year, and minor revisions and additions have occurred during the current reporting year. Target (e) was accomplished in previous reporting year and was published in early 1979. Additional references and/or revisions are being compiled in anticipation of supplementary volumes.

Targets (f), (g), and (h) are ongoing in nature and are handled as appropriate.

There has been a measurable increase of assistance to all categories of users. The receipt of information requests takes priority over other ongoing projects. Target (i) was necessary to review objectives and what remained to be accomplished, to set priorities and determine appropriate courses of action in light of various possibilities, e.g. continued limited operation, a temporary suspension of all activities, incorporation into a different unit. Discussions with the Project Director, all project personnel and College advisors, library liaisons and all related personnel to the project were consulted. It was also determined to request an extension and explore more than one proposal for continued operations of the information center.

Target (j) involves a great deal of background research, discussions and planning to determine what is feasible and what parameters of service can be achieved. Since there are no specific or comparable models to look at, much of the design is based on technical feasibility, previous experience, demand and knowledge and anticipated cooperation and demand for services. The center would provide microfiche copies of any document cited in the database. The microfiche copies would be produced in-house with newly developed equipment and supplied to selected research stations worldwide and requestors on demand. At the end of three years, the document delivery system would be evaluated and perhaps serve as a model for other projects.

Target (k) is ongoing in nature and promotes the continuance of a cooperative and effective service unit.

Target (l) is also basically ongoing since it involves complex communication, cooperation and operational mechanisms. The computerized

system is well able to handle the technical aspects and the personnel involved are enthusiastic and interested in further developing the potentials.

Target (m) affected internal mechanisms of operation and techniques which would maintain the essential functions of the center e.g. the continued receipt of mail requests, the referral of important inquiries, the flow of acquisitions still coming in after the project completion, etc.

Assumptions were made in the drawing up of these targets that would have a negative impact if they should prove to be incorrect. The assumptions, unchanged since the first reporting year, are as follows:

(1) It is assumed that U.S. and developing country institutions will cooperate with UCR in regard to the initiation and strengthening of linkages, exchanges and visits by staff and students, information exchange, and other cooperative activities.

(2) It is assumed that existing University staff and facilities will be able to absorb increased workloads from project tasks (i.e. keypunching, ordering of materials, cataloging), or that project funds can be used to augment these facilities as needed.

(3) It is assumed that material ordered and requested for the collection will prove to be available.

The means of verifying progress made in this category include on-site visitation, reference request statistics, inspection of the data base printout, the project Annual Reports, and descriptive articles

prepared by the Project Librarian and appearing in information science and agricultural development literature, trade publications, and CIDNET brochures.

### 3. Accomplishments

a. **Accumulative** - The data base now contains 13,500 entries of accessible information and continues to expand through the acquisition of materials in new subject parameters, worldwide geographic scope and utilization of the document exchange system. Current acquisition procedures involve the current awareness services of ASCA and other data bases as appropriate and the African Imprint Library Services approval program. Gifts, exchange publications, and the scanning of all current agricultural bibliographical materials remains part of the ongoing procedures. Awareness of and publicity about the project is increasing as a result of publications, personal and organizational contacts, correspondence, referral/exchange systems (as exemplified by CIDNET) visitor programs, research personnel contacts and referrals and involvement in professional meetings. The Research Team has developed various new projects, and library support of these activities has significantly increased. The number of visitors to the Information Center, both national and international, has also continued to increase. All these aspects have contributed to the worldwide reputation and success of all project activities and achievements.

b. **Reporting Year** - At the end of the reporting year and

grant expiration the MUSAT:sra data base had over 13,500 entries and some 1,000 still in process, made up of both the backlog of scanned journal articles from various sources and new acquisitions and orders. New selection tools are continually being utilized as the AID Research and Development Abstracts, Commonwealth Agricultural Bureaux (CAB) abstracts, AGRIDOC and IRRICAB bibliographies. In addition, there is a steady flow of worldwide organizational catalogs and materials sent free of charge through our exchange program.

In the philosophy of the grant concept and of the Information Center, the Project Librarian has worked with the UCR Library's Collection Development Department in drawing up guidelines that define and describe the kinds of material being purchased. Because the project crosses a number of discipline lines, continued coordination is necessary to avoid duplication or conflict with other collection development consultants for the academic disciplines. The Collection Development profile is revised and updated every year for inclusion in the Collection Development Department manual for campus referral.

In accordance with University-wide library policy, the UCR Serials Decision Committee reviews each new serial title proposed for addition to the MUSAT:sra Information Center; there is also a Serials Deselection Committee which oversees the elimination of expendable serials from the collection in order to meet the problem of increasing journal costs and decreasing budget allocations. Although the serials selected for the MUSAT:sra collection by the Project Librarian are automatically approved, the Project Librarian has been working closely with these groups to forestall any conflict and to ensure the maintenance of the collection after the term of the grant.

Material for the MUSAT:era Information Center collection is ordered from a wide variety of sources. A good deal is produced by U.S. publishers or other organizations, but the bulk is published abroad, either in Europe or in the developing countries. U.S. dealers can be called upon for acquisitions from many European publishers, and African Imprints Library Services, a New York based firm, has provided excellent service in acquisition of a large number of African publications. For the most part, however, ordering must depend on direct correspondence with the publishers or agencies overseas; the large volume of orders involves the Acquisitions Department in a great deal of clerical work, and necessitates procedures for dealing with foreign languages, currencies and billing conventions. In addition, special attention must be given to following up on orders.

The Resource Directory for Agricultural Research appeared in early 1979 and has been doing well based on summary reports from the publisher, G. K. Hall. It is in the "Bibliographies and Guides in African Studies" series by G. K. Hall and contains over 1500 citations for reference. The citations are retrievable by name, organization, subject, geographical area of expertise and location. The Directory complements the previous project publication of the geographic index of the project data base and changes and additions are being compiled in the event of an updated edition. Information from the Directory is often included in appropriate information requests and has received a favorable response. The Proceedings of an International Symposium on Rainfed Agriculture in Semi-Arid Regions which was held by the project April

17-22, 1977 is also available. It represents papers on all aspects of dryland farming and includes numerous papers from UCR faculty and graduate students. The Proceedings have been receiving continued demand and have been and continue to be distributed worldwide.

In anticipation of the grant expiration the phasing-down aspects of the operation had to be planned and implemented. While the continued operation of the Information Center was not possible, a complete and permanent closing was also not envisioned. Alternative plans had been anticipated and a comprehensive three year proposal, based on services the center could offer worldwide, was sent to AID, January 23, 1979. Due to reorganizations, personnel changes and funding uncertainties with AID on the proposal, action has been delayed.

The first area to be reviewed and basically suspended was the acquisition system. All outstanding orders were reviewed and appropriate action taken. Selections for current materials were still made, but held until project resumption for ordering purposes. Mechanisms were established whereby any materials arriving after the project's end would be held or routed through alternate channels. Arrangements were made with the UCR Libraries to accomplish these objectives. The same type of provisions were made for center correspondence and continuing serial publications. Letters were prepared and sent to the weekly citation services (ASCA) and the book approval vendor, (African Imprints Library Services) to suspend until future notice their services to the center.

Status of the budgeted accounts were requested to determine final disposition and expenditures allowed on the balances available for center operation.

In respect to the computerized systems operation, discussions were held and arrangements made to maintain the computer tapes and to establish a cutoff date on addition of new entries. New entries compiled after the cutoff were kept at the center until such time that services were reinstated.

Incoming and backlog materials were prioritized and handled accordingly.

CIDNET has continued to operate with cooperation and increasing efficiency, and CID member universities have increased with the addition of Idaho University and Washington State University in this reporting year. Member universities report increased usage of materials and the referral system is operating smoothly.

A 3-year grant proposal was prepared under the direction of the Project Director and submitted to AID in January, 1979, entitled "CIDNET International Information Center".

The primary objective of the proposed project is to make agricultural research information available to researchers and organizations in the developing countries. One of the basic information needs in these countries is access to materials such as monographs, serials, research reports, and maps and climatic data. The CIDNET Information Center's primary activity would be to provide such materials through a

document delivery system to researchers in appropriate developing countries of Africa, the Middle East, South and Central America, and some areas of the Far East.

Initially, the CIDNET Information Center would establish its document delivery system from the combined data base of the five participating universities, which presently contains 32,000 bibliographic entries reflecting the resource collections of those institutions.

The secondary objective of the project will be to ensure the currency of the document delivery system. The Information Center will supply the participating universities with new lists of bibliographic citations from which they may select updated material relating to their interest profile areas for inclusion in their data bases. It is assumed that only minimal grant support from the project need be provided to the CIDNET universities to maintain the updating of their data bases. As new interest profiles are generated by users, these also will be incorporated into the CIDNET system. The currency of the system will be assured through continued bibliographic support, refinement of retrieval systems, and various updating activities as needed.

The third objective of the project is to produce microfiche copies of the entire data base and to distribute these with fiche readers where needed to a specified number of research centers in developing countries and to some other relevant organizations. It will be largely from the microfiche files around the world that researchers

in developing countries will select those documents they need. These microfiche files at selected research centers will constitute the heart of the document delivery system. This proposal is still in the consideration phase at AID.

The fourth year comprehensive project review May 2-4, 1978 was accomplished and out of that assessment grew the decision to prepare an extensive 3-year proposal for expanded services to developing countries. Based on the favorable receipt of the first exhibition "Glimpses of Traditional Agriculture in Upper Volta", another exhibit was prepared and displayed entitled "Sahel: the drought that created a flood of interest". The exhibit looked at the region of West Africa known as the Sahel, consisting of six countries. Some aspects of the drought and the people and conditions in the six countries are reviewed.

The column for the UCR Libraries newsletter entitled "Memoirs from MUSAT:era" was continued by the Project Librarian to relate notable acquisitions, special events or projects and to convey awareness of international visitors.

Microfiche copies of the project indexes are available and this facilitates the acquisitions and references processes, while providing a compact listing tool for our 13,500 entries. The Information Center currently houses 4,700 items, as well as providing reading space for users and working space for the Information Center staff to handle reference questions, locate materials and process acquisitions. This reflects a decrease in the number of items housed since approximately

1,500 items have been transferred to the main campus library collections and a designated area in the Bio-Agricultural Library to provide the Information Center with vital working space.

The State of the Art manuscript appeared as volume 34 in the Ecological Studies series of Springer Verlag publications under the title, Agriculture in Semi-Arid Environments, edited by Anthony E. Hall, Glen H. Cannell and Harry W. Lawton, 1979. The publication examines dryland farming techniques for systems where rainfall is limited and irrigation water scarce and discusses dryland farming systems that have been used in the past and evaluates the systems as potential models for contemporary agricultural development. The Project Librarian prepared the taxonomic index for this publication in consultation with the editors. This work promises to be a valuable contribution to researchers worldwide and reflects the need for an integrated multidisciplinary approach to agricultural development.

Other activities included preparation of comprehensive specialized bibliographies, e.g. cowpeas, jojoba, and guayule. The quality and efficiency of the Information Center services are due in large part to the excellent talents and computer expertise of the library assistant, Pat Copeland. The cooperation and assistance provided allowed the Project Librarian to accomplish many more project contributions than would have been possible. Articles, announcements, brochures, etc. were prepared by the Project Librarian to insure awareness of center services and to maintain a worldwide focus.

## B. Objective/Output No. 2: Network of Worldwide Linkages

### 1. Narrative Description

The establishment of an Information Center and a network of worldwide linkages are closely connected. The formation of organizational linkages and personnel contacts has been an important means of acquiring new resources for inclusion in the data base.

In the reporting year there has been continued and expanded personal and professional ties with the French research organizations of Institut de Recherches d'Agronomie Tropical (IRAT), Centre National de la Recherche Scientifique (CNRS), l'Office de la Recherche Scientifique et Technique Outre Mer (ORSTOM), and West African counterparts, such as Centre National de Recherches Agronomiques (CNRA) in Senegal and the International Institute of Tropical Agriculture (IITA) and the Institute for Agricultural Research in Nigeria and other organizations in Upper Volta, Mali and Niger. New linkages have been established with organizations as:

Royal Tropical Institute (Netherlands)

International Food Policy Research Institute (IFPRI) (U.S.-D.C.)

Institute of Agricultural Research and Training, University of

Ife, Moor Plantation (Nigeria)

Groupement d'Etudes et de Recherches pour le Developpement de

l'Agronomie Tropicale (GERDAT) (France)

Bayreuth University, Lehrstuhl fur Pflanzenokologie (West Germany)

International Institute for Land Reclamation and Improvement

(ILRI) (Netherlands)

Instituto Centroamericano de Investigacion y Tecnologia Industrial  
(ICAITI) (Guatemala)

American University in Cairo. Desert Demonstration Development  
and Training Project. (Egypt)

CSIRO. Division of Tropical Crops and Pastures. Cunningham  
Laboratory. (Australia)

Lanzhou Institute of Desert Research. Academia Sinica. (China)

Contacts with these organizations and many others have already produced a flow of valuable material exchanges, faculty contacts and visitor exchange opportunities with possible student educational exchanges. In the Soils Dept. alone there are several student exchange grants to specifically study arid/semi-arid areas. The resources have now been developed and are available for opportunities of this type.

These linkages were further strengthened by the following activities:

- 1) Visitation by the Program Director at ORSTOM and IRAT headquarters in Paris, and with their scientists in Senegal and Upper Volta. Meetings were also arranged with various government agencies in Senegal and Upper Volta and with scientists at their research stations in these countries. Visits were made with the AID Missions and with ICRISAT's West African headquarters at Dakar and their research station in Upper Volta.
- 2) A staff member visited Paris and Senegal in search of information on Acacia albida, providing new contacts and strengthening existing ones.

3) A meeting was held and a proposal on cowpea production developed with representatives from Senegal, IITA, Cornell University, Boyce Thompson Institute and UCR in Dakar in June. This was a very productive meeting and has greatly strengthened UCR's linkages with Senegal and IITA. Through these meetings a strong interest was created for developing a cowpea project to be conducted in Senegal that would have application to other semi-arid regions.

4) The scientist exchange program was continued with ORSTOM. A nematologist from ORSTOM's research laboratories in Dakar spent the year at UCR doing research on nematode population problems in semi-arid dry soils. This was a cooperative study with nematologists at UCR. Plans were formulated to continue the exchange program with ORSTOM during the fifth year of the grant when scientists from both institutions would take part in the program.

5) The 18 month project in Upper Volta--an indigenous approach in studying farming methods and systems on a village level--provided an opportunity for many visiting scientists to gain knowledge of the Ouahigouya region by visiting and touring the area with the project director. The study provided ICRISAT with assistance in their plant breeding testing program for sorghum and cowpea. The Upper Volta project director located sites and recorded data for each of the sites located within the village areas of his project. These linkages and those with visitors provided a base for extending worldwide linkages and strengthening existing ones.

6) Visitors to MUSAT:era from many agencies have provided a base for various worldwide linkages with developing country governments, including embassy personnel, research scientists, agricultural and rural development officers and others.

7) Consortium for International Development (CID) has provided many contacts and opportunities in establishing worldwide linkages.

Contacts and information exchanges have continued with the Centre Regional de Formation et d'Application en Agrometeorologie et Hydrologie Operationelle (AGRHYMET) in Niger, Comite Inter-Africain d'Etudes Hydrauliques (CIEH) in Upper Volta, Comite Permanent Interetats de Lutte Contre la Secheresse (CILSS), the Agricultural University at Wageningen in the Netherlands, and the International Irrigation Information Center and the Volcani Center in Israel.

Information exchange linkages have been maintained with the consulting agency Societe Africaine d'Etudes et de Developpement (SAED), the International Institute for Tropical Agriculture (IITA), and the Institute of Agricultural Research at Samaru, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and All-India Coordinated Research Project for Dryland Agriculture (ICAR).

Additional contacts and exchanges have been made with key regional units such as the International Livestock Centre (ILCA) in Ethiopia, Institut Senegalais de Recherches Agricoles (ISRA) in Senegal, and West Africa Rice Development Association (WARDA) in Liberia. Cooperation for information distribution was established with the International Food Policy and Research Institute (IFPRI) in Washington, D.C., the Institut National de Recherche et de Documentation de Guinee in Guinee, the

Casamance Project in Senegal, the Djibelor Research Station of ISRA in Senegal, Soils & Water Research Institute in Egypt, and the Department of Agricultural Technical Services in the Republic of South Africa.

CIDNET, the information network for CID, has provided contacts from various countries where CID projects are being conducted, such as Niger, Chad, Egypt, Bolivia, Senegal, Upper Volta, Saudi Arabia, Sudan, Yemen, Gambia and Cape Verde. One of the major contributions and accomplishments of the Information Center services has been the tremendous worldwide response to the document exchange program. Not only has it served as a great resource for relevant and cost-free materials, but provided institutional cooperation, awareness of programs and services and supplied names, addresses and research interests of personnel related to project research activities. The regular mailing list for this exchange system follows.

INTERNATIONAL/NATIONAL COOPERATIVE EXCHANGE PROGRAMORGANIZATIONAL CONTACTSCENTRAL AFRICAN REPUBLIC

Bureau Inter africain des Sols  
B.P. 1352  
Bangui, CENTRAL AFRICAN REPUBLIC

COLOMBIA

Aracely de Tovar, Exchange  
Centro Internacional de  
Agricultura Tropical  
Biblioteca  
Apartado Aereo 67-13  
Cali, COLOMBIA

COSTA RICA

Amyel de Locatelli,  
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Andean Zone  
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Dr. Abdel Salam Gomaa  
Director, Wheat Research Section  
Field Crops Research Institute  
Agriculture Research Centre  
Giza, Cairo, EGYPT  
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Dr. Mohamed Samir Heikal  
Soils & Water Research Institute  
Agriculture Research Centre  
Cairo University Street  
Giza, EGYPT

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 Relations Dept.  
 Institute of Agricultural Research  
 P.O. Box 2003  
 Addis Ababa, ETHIOPIA

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 Institute of Development Research  
 Documentation Centre  
 Addis Ababa University  
 P.O. Box 1176  
 Addis Ababa, ETHIOPIA

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 Claudie Rox, Librarian for the  
 Director of Documentation  
 International Livestock Center for  
 Africa  
 P.O. Box 5689  
 Addis Ababa, ETHIOPIA

FRANCE

AGRIDOC International  
 202, Rue de la Croix-Nivert  
 75738 Paris CEDEX 15, FRANCE  
 Attn: G. Chabert  
 Responsable de l'appui  
 technique

GHANA

L. Agyei-Gyans, Serials, Gifts  
 & Exchange Librarian  
 Council for Scientific &  
 Industrial Research  
 P.O. Box M.32  
 Accra, GHANA

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 Librarian  
 University of Cape Coast  
 Cape Coast, GHANA

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 Librarian, The Balme Library  
 University of Ghana  
 Legon, Accra, GHANA

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 Librarian  
 Univ. of Science & Technology (UST)  
 University P.O.  
 Kumasi, GHANA

GUINEE

Koly Kassery Kourouma  
 Directeur de la Division des  
 Sciences Exactes et Naturelles  
 Institut National de Recherche et  
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 Nairobi, KENYA

LIBERIA

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 E.J. Roye Memorial Bldg.  
 P.O. Box 1019  
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 63 Mauritskade  
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 Projects in the Sahel Zone  
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 d'Application en Agrometeorologie...  
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 I. Inse, Director  
 Documentation Center of the  
 River Niger Commission  
 B.P. 933  
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NIGERIA

Ahmadu Bello University  
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NIGERIA (Cont'd.)

Mr. R. Salami, Ag. Librarian  
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 International Institute of Tropical  
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 Oyo Road  
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 Mrs. R.E. Udoh, Principal Librarian  
 National Cereals Research Institute  
 (Library Division)  
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 P.M.B. 5042  
 Ibadan, NIGERIA

PHILIPPINES

(Mrs.) Lina M. Vergara, Chief Libr.  
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 P.O. Box 933  
 Manila, PHILIPPINES

SENEGAL

Centre de Documentation pour le  
 Programme de Developpement du  
 Bassin du Fleuve Senegal  
 B.P. 383, Rue Durat  
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 Gora Beye  
 Centre National de Recherches Agron.  
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TANZANIA

Library  
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 P.O. Box 643  
 Morogoro, TANZANIA

U.S.

Victoria Frie, Resource Librarian  
 ACTION Library, MA07  
 806 Connecticut Ave., N.W.  
 Washington, D.C. 20525

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 Gretchen Walsh, Head  
 African Studies Library  
 Mugar Memorial Library  
 Boston University  
 771 Commonwealth Ave.  
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 G.V.V. Rao  
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 Africana  
 Melville J. Herskovits Library of  
 African Studies  
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UPPER VOLTA

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## 2. Targets for the Reporting Year

- a) Publication of the Resource Directory for Agricultural Research in Semi-Arid Regions by G. K. Hall.
- b) Continued correspondence with linkages and new contacts through an exchange of publications, information and ideas.
- c) Sponsor a CIDNET conference to update members on activities, share problems and discuss potentials and future directions.
- d) Continued documentation support of research project publications and activities.
- e) Increase awareness and demand for Information Center services by a broader base of publicity including articles, exhibits and participation in national/international meetings.
- f) Exploration of inexpensive approaches to document retrieval and delivery and preparation of funding proposals.
- g) Continue personal contacts with scientists and government leaders in the developing countries, international organizations, AID Missions and other institutions.
- h) Completion of the State of the Art on Acacia albida.
- i) Develop with cooperation from other organizations a preliminary proposal for a project in cowpea production and related activities to be conducted in Senegal.
- j) Continue the scientists exchange program with developing countries.
- k) Complete the MUSAT:ra project in Upper Volta.
- l) Review center operations, determine priorities and phase-down.

a) Refinement of centralisation plans for CIDNET information network activities and services.

The magnitude of accomplishment of these targets has been determined by responses received from the accomplishment of the targets:

a) The Resource Directory for Agricultural Research in Semi-Arid Regions was published by G. K. Hall, c1979.

b) Correspondence continues at a steady rate with new contacts increasing and leading to the establishment of linkages with organizations, personnel and document exchanges.

c) A CIDNET conference was initiated and hosted at UCR to share ideas on the collaborative networking system. Follow up, discussions and contacts with new personnel have been continued to keep the concepts alive and functioning. Refinement of procedures and services have been accomplished as appropriate.

d) Assistance provided has resulted in the publication of the Proceedings of the International Symposium on Rainfed Agriculture in Semi-Arid Regions April 17-22, 1977, Edited for publication by Glen H. Cannell, c1978.

Also published was the project State of the Art as Agriculture in Semi-Arid Environments. Edited by Anthony E. Hall, Glen H. Cannell and Harry W. Lawton, New York, Springer Verlag, c1979.

e) The Project Librarian produced and distributed literature about project activities and services through articles, brochures, exhibits, meeting attendance, etc.

f) Continued utilization of microfiche as the most flexible and cost-effective means of updating the computerized data base holdings and

dissemination of the information to as wide a base of individuals as possible. To further develop and promote the potentials of document delivery, proposals involving document delivery systems were designed and submitted to appropriate funding agencies. (They are still pending.)

g) Visits to France, Senegal and Upper Volta were made by the Project Director to strengthen existing linkages and to develop new contacts for the State of the Art Acacia albida project leader.

h) The State of the Art for Acacia albida was completed and copies were sent to AID/Washington for distribution as appropriate.

i) A preliminary proposal was developed in cooperation with Senegal, IITA, Cornell University and Boyce Thompson Institute.

j) An ORSTOM scientist from Dakar spent the year working in the UCR Department of Nematology.

k) The collection of data in the Upper Volta project was completed in March and the project terminated.

l) Center operations were reviewed, priorities determined and mechanisms initiated to phase-down the active operations to a maintenance level which could be suspended without losing vital functions.

m) The continuance of extensive services is based, in part on the centralization of the CIDNET network resources. A plan of action was developed which was then expanded into a proposal to insure an effective and viable information center.

Assumptions were made in the drawing up of these targets as follows:

1. It is assumed that AID/W will continue to provide assistance in

the initiation of linkages with developing countries in identifying training needs of institutions and individuals, and sites for cooperative activity in the developing countries, and in the exchange of information as part of the linkage network.

2. It is assumed that institutions in the U.S., other developed countries and less developed countries will cooperate with UCR in the initiation and strengthening of linkages, exchange of information and visits by staff and students and other cooperative activities.

The means of verifying progress made in this category might include on-site visitations, review of correspondence files and computerized indexes, the project Annual Reports and other in-house and external reports, including publications in professional literature by the Project Librarian and other Project staff.

### 3. Accomplishments

#### a. Accumulative

During the first reporting year bulk mailings were made to research institutions listed in a number of directories covering arid lands, agricultural development and African studies. Nearly 1,000 letters and descriptive brochures were sent out, opening up several hundred files of active correspondence. Often, inquiries about publications we desired to order netted replies that led to further linkages. Additional references were added to the preliminary bibliography during the second

reporting year and another mass mailing was made to research projects identified through the Smithsonian Scientific Information Exchange which, because of its input from CARIS, was able to provide a large number of African research project contacts.

During the first reporting year the TRIM program was tailored for use in developing a directory which was then indexed by name, organization, location, subject field and geographic area of interest. Complete addresses are printed but are not a searchable field of information. Searches can be made on any of the fields or combinations thereof. The directory is keyed to the correspondence files which yield fuller information than that recorded on computer.

The second reporting year involved expanded travel and personal contacts for cooperative linkages through joint research and training projects. Attendance at professional meetings and communication with colleagues aided progress and successful results and valuable contacts were obtained.

The project hosted several visitors as a result of contact with the African American Institute's visitor program and the Institute of International Education. Excellent progress was made in the area of organizational linkages with ISRA and ONRA in Senegal, and IRAT, IITA, ORSTOM, ONVS and ICRIRAT to name a few. The project played an active role in the activities of the Consortium for International Development (CID) and provided background information for travel teams. In September of 1975 CIDNET emerged as a new dimension of CID, and the MUSAT:era Project Librarian was designated as the CIDNET reference coordinator. CIDNET has provided closer affiliation with both national and international research organizations and individuals.

Direct communication through visitation with FAO personnel in Rome resulted in a cooperative desire to link both Bureau Interfricain des Sols (BIS) and AGRIS TROPICAL to the CID network. As CIDNET develops this linkage has application potential since MUSAT:era and CIDNET are both interested in cooperative projects with centers in the developing countries and in providing information services to researchers in these countries. BIS, located in Bangui, Central African Republic, provides information on soil sciences for Africa by analyzing and disseminating the information through the periodicals "Bulletin Analytique Mensuel" and "Sols Africains" and they participate in the AGRIS TROPICAL soil sciences sub-network to cover the soils and natural resources literature for Africa.

During the third year the International Symposium on Rainfed Agriculture in Semi-Arid Regions provided many new personal contacts worldwide. Participants visited with faculty and staff at UCR and toured research facilities. Among the participants in the Symposium were key contacts affiliated with MUSAT:era projects at Riverside and in the developing countries. Several of these individuals remained for a short time following the meetings and this provided a cementing of relationships and planning for new and continuing projects in cowpea research and in the scientist exchange program.

Cooperation and exchange of information with the Niger River Commission and Comite Interfricaine des Etudes Hydrauliques (CIEH) have continued. Initial contacts on the basis of an exchange of materials have been made with the newly formed CILSS/WHO Sahel Program, AGRHYMET Center (Agriculture, Hydrology and Meteorology), a linkage which provides

an excellent complement as it adds the dimension of meteorological sources. Valuable personal contact and potential linkage was developed at the Symposium with the Niger Institute for Agronomy Research and the INRAN Laboratoire de l'Elevage in Niamey, Niger. These organizations deal with areas of range management and livestock production and can provide another area of agricultural interest to our linkage program.

As a result of linkages previously developed with the Central Treaty Organization (CENTO), which represents seven leading agricultural institutions in Iran, Turkey and Pakistan, and scientists from that region attending the Symposium, requests for research information continue to be received.

A major affiliation was developed with the Volcani Institute of the Agricultural Research Organization in Bet Dagan, Israel in the first year of the program. This center deals with various aspects of dryland farming, but of particular interest to the project is the concentration on sorghum drought stress studies and various other crop and irrigation projects. In consideration of the project's concern for increasing the adaptive research capability of UCR faculty, two Postdoctoral Fellows from the Volcani Institute have been supported by MUSAT:era to work on research activities related to the program. This linkage was further extended by a visit to MUSAT:era by the Managing Director of the International Irrigation Information Center (IRRIC) of the Volcani Institute. IRRIC is a member of the International Development Research Center (IDRC) in Canada and publishes the Current Annotated Bibliography of Irrigation (IRRICAB). This center utilizes seven data bases and cites 1,250 journals. The Managing Director expressed particular interest in affiliating with CIDNET. Since IRRICAB deals with agriculture in developing countries this linkage is highly desirable.

New Central American linkages were initiated as a result of inquiries from the Centro Internacional de Agricultura Tropical (CIAT) in Colombia. CIAT is an international research center dealing with tropical agricultural research and cooperates with the Colombiano Agropecuario (ICA) and other research organizations. There are 40 experimental stations involved and numerous projects are being conducted in dryland farming; CIAT's willingness to cooperate offers an additional resource to the worldwide network linkage system.

As a result of the project's International Symposium a new professional linkage was achieved with the Agricultural University Wageningen of the Netherlands, whose tillage laboratory conducts projects on tillage systems and soil management for semi-arid regions, with special reference to the Sahel. Information has been exchanged and reference assistance supplied and many original publications received in turn which have been very useful and reflect some of the latest technical and modelling aspects of agricultural research.

The Scandinavian Institute of African Studies (SIAS) operates as a documentation and research center on African affairs in the Sahel region. Exchange of information and documents provided a useful linkage as SIAS became involved in a major project of the present state of knowledge, future implications of research on water use, and water needs and resources in Africa. The MUBAT:ers Information Center was contacted by the Documentation Center on Science and Technology for National Development in Africa of the Research Policy Program at the University of Lund, Sweden. They expressed interest in exploring alternative approaches to better utilization of science and technology to meet basic human needs and provide a publications

exchange program. They also publish a newsletter and are interested in creating an informal and open-ended network as an "information exchange".

Vital linkages were achieved through an Information Exchange for Development in the Sahel Conference at Michigan State University. Conference participants included L. B. Guindo, head of the Documentation Center for West Africa Rice Development Association (WARDA) and Ouamane Silla of the Comité Permanent Interetats de Lutte Contre la Secheresse dans le Sahel (CILSS). WARDA utilizes the computer programs of the FAO Documentation Center. Although the main objectives are to provide an information service on all aspects of rice production to member nations, the structure of WARDA is such that it can be utilized as a document delivery system for all types of research material in addition to rice-related information. The member nations include Benin, Gambia, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo and Upper Volta. Services which could be utilized for document delivery include computer facilities, microfiche production, and microfiche readers at all centers in the member countries. An exchange program was initiated.

As the Institute of the Sahel is established through the Club des Amis du Sahel, mechanisms for coordinating and sharing information can be utilized through the organizational structure. The Institute is attempting to identify, encourage and support information services already in existence in Africa, and to establish cooperation between a network of Sahelian information services and information centers of international agencies. This linkage could establish a large network of referral services accessible to meet the requests of users. One of the goals mentioned by CILSS involves network sharing among users of the information

services. A recipient of information from centers within the network would in turn be encouraged to supply appropriate centers with copies of reports, records of data, etc. In addition, there would be no limitation on the kinds of information or the format to be collected or provided for dissemination; this recognizes that a wide variety of media is necessary for the success of development efforts.

While in some cases initial contacts had already been made through correspondence, continued and strengthened linkages have been obtained through personal research and project contacts, which seems to be the most successful means of maintaining and furthering linkage interests. Linkages in themselves indicate an on-going and meaningful exchange of ever-expanding possibilities.

Activities and continued linkages with the Consortium for International Development (CID) have continued to be a strong part of the MUSAT:era program. CIDNET linkages have involved providing information for CID travel teams. Reference questions as a result of CIDNET activities have continued to increase from national and, in the form of Society for International Development (SID) referrals, from international sources. MUSAT:era has been designated and is functioning as a major U.S. source of information for this service and new linkage sources have resulted from this cooperative effort.

Another affiliation resulting from CIDNET activities is with Midwest Universities for International Activities, Inc. The Program of Advanced Studies in Institution-Building and Technical Assistance Methodology (PASITAM) has initiated an exchange of materials with the MUSAT:era Information Center such as the PASITAM Newsletter and other resources of the Documentation Center at Indiana University.

During the 4th reporting year there were continued research and personal contacts, linkages formed by project correspondence, cooperative projects, publications, CIDNET and AID referrals and continued participation in the African-American Institute and the Institute of International Education visitor programs. Prospects continued to point toward the development and establishment of an international document delivery program with expansion to cover developing areas in Africa, South and Central America, the Mideast and other applicable climatic regions.

Additional organizational contacts involved the International Council for Research in Agroforestry (ICRAF) through the Royal Tropical Institute in Amsterdam. The Council addresses itself to problems in agroforestry, which is defined as a sustainable management system for land which increases overall production, combines agricultural crops, tree crops and forest plants and/or animals, and applies management practices compatible with local population cultural patterns. ICRAF expressed great interest in services cooperation since they will be permanently located in a developing country where access to information is difficult.

The Societe d'Etudes et de Developpement Agricoles (SEDAGRI) in France supplies information and documentation for rural development in Africa. Services cover a question and answer service, an indexing service and a specialized information service of subject profiles. This proved to be a valuable contact since SEDAGRI deals primarily with francophone Africa and plans also to cooperate with established African information centers. Information was exchanged with Miss Simone Argoud, Head of Documentation Services at the Institut de Recherches pour les Huiles et Oleagineux (IRHO) in France. Miss Argoud felt that IRHO

activities overlapped ours in the fields of dryland farming, drought, irrigation and the oil crops of *Joba*, peanuts, safflower and sesame. They have continued document exchanges.

Through the African-American Institute (AAI) visitor program contacts were made with Mr. Koly Kourouma of the National Institute of Documentation and Scientific Research in Conakry, Guinea and Mr. Sekou Sissoko, Director of Agriculture, Ministry of Rural Development in Mali. Both visitors desire to maintain contact and to participate in our exchange program. The Institute of International Education (IIE) sent us Mr. Kamil Ali Mohamed, Press Relations Director for the Office of the President in Djibouti. Mr. Kamil is to be Djibouti's first representative to the United States. Djibouti, in northeast Africa, has a population of 100,000 with a dry and bare geography and sparse and erratic rainfall. The interest in our agricultural activities and information services is obvious, and we anticipate continued exchanges.

The Embassy of South Africa in Washington, D.C. arranged for a 2 day visit at UCR and our project for the study tour of C. F. Beyers and J. Volschenk, who are, respectively, Director of the Department of Agric. Technical Services, Soil Science Section, Winter Rainfall Region in Stellenbosch and Director, Dept. of Agric. Technical Services, College of Agric. and Research Institute in Potchefstroom. Mr. Beyers and Mr. Volschenk were interested in information on soil and plant nutrition and were genuinely interested in the organization and operation of our Information Center. They will be utilizing our services in the near future as well as informing colleagues of our services.

An extension worker from Botswana, Mr. Timothy Mahlanza, consulted the Information Center to further his extension activities in the areas of dryland agriculture, crop production of cowpeas, and livestock production. Materials were sent to him on these topics.

Through CIDNET affiliation we were able to provide varied and numerous services such as for the recent 2 year livestock project in Upper Volta. It was also rewarding to note the increasing number of repeat clientele, that is organizations and individuals who have received information, specialized bibliographies and reference services in the past and are requesting new information.

Representative new associations made on a national basis included the Earth Satellite Corporation (EarthSat) of Washington, D.C. with search requests on groundwater and geology for projects in Upper Volta and Ghana. The Information Center has become a primary resource for this country for a new Mauritania project. The documentation phase of the research project is headed by Juliana Heyman for RAMS-Mauritania (Rural Assessment/Manpower Study). Most of our materials on Mauritania were filmed for reproduction by Ms. Heyman for utilization in a specialized documentation package. We also were provided with microfiche copies in the process.

The Southwest Research Institute in San Antonio, Texas is involved in a program to review and synthesize AID-sponsored research in the field of water resources management for agriculture. We were involved, along with the project research program, in interviews explaining and demonstrating our technical information systems. The team was supplied with information concerning the scope and content of our computerized information retrieval system and the preliminary run of the Resource Directory was used for their mailing list.

There was a marked increase in the number of inquiries from U.S. universities requesting detailed information on our data base and retrieval systems. Numerous specialized research projects with supporting documentation systems are being established throughout the nation and, as a result of our publicity efforts, our activities are being reviewed as a model. This has occurred with Kansas State University for grain storage literature, Ohio State University for expanding its programs to dryland agriculture in the Middle East, the University of Missouri-Columbia with a research project in atmospheric science for the Sahel and other semi-arid tropical regions of Africa, and the University of Dayton's Strategies for Responsible Development (SRD) group with an integrated agricultural development project in Niger.

Various national inquiries related directly to our network activities and resulted in additional service requests. The University of Pittsburgh included us in a major study of library resource-sharing networks to determine how networks may operate. The paper has been published and is available as "Resource Sharing Networks: Functions". Indiana University's International Development Institute Documentation Center director, Mr. Richard A. Steele, was particularly interested in our data base and Thesaurus.

In early May 1978 AID conducted a comprehensive four year review of our program. Materials and a Logical Framework Matrix were organized for the evaluation process and a discussion of and tour of the project Information Center was included. Results of the review have been favorable and, as a result, extensive planning is underway to prepare a new grant proposal focusing on the Information Center, objectives of which

would include international document delivery through microfiche format and the full utilization of the resource collection of the CIDNET member universities.

The Information Center operated at peak level of services in the 4th year and many of its potentials were realized through a wide variety of activities. In reviewing the statistical breakdown of services requested and delivered (see Appendix III-A) we are convinced that an expanded program based on a document delivery system will utilize the data base and retrieval services to utmost capabilities and outreach potentials.

A formalized working conference with CIDNET was initiated by the Program Director in September of 1977 to review and discuss CIDNET progress and to formulate plans for future activities and objectives. Discussion centered on the data bases which are continuing to be developed by each of the CIDNET member universities. All five data base conversion procedures are completed and machine-readable search capabilities are available. CID provided funds to Arizona University and Utah State University to assist in getting their information on the TRIM system; Colorado University has been able to increase their TRIM output as a result of funds made available to them from local sources; Oregon State University has continued to develop its data base from AID 211(d) grant funds that will be available through 1980. Since the five data bases are completely searchable, means are being explored to use the total data base of CIDNET for a document delivery system designed for the developing countries. A microfiche system is being investigated for that system and a microfiche of the MURAT:era data base has been made and copies of it presented to CIDNET. This is a beginning point in developing a future program for an information delivery system to the developing countries.

b. Reporting year

Accomplishments in this Objective/Output have included the continued response to all types of reference, information, services, consultation requests, active involvement with visitors and the building and expansion of the data base collection. Due to the end of the project, there was a necessary review and concentration with phasing-down activities. As research projects were concluded, the operations of the Information Center continued at a steady pace, but with different objectives. Collection development guidelines were reviewed and revised with the aim of strengthening particular subject areas rather than the entire base generally. The concluding five year project has produced programs, established faculty expertise and developed an excellent resource collection on dryland agriculture. The Information Center services can now be further applied by a worldwide focus. New funding proposals have been prepared in light of these objectives.

Our linkages have produced special benefits in terms of acquisitions. The Tippetts-Abbott-McCarthy-Stratton (TAMS) Agricultural Development Group supplied a gift of seven volumes entitled, Savanna Regional Water Resources and Land Use, 1979, as a result of extensive research undertaken at the Interafrican Committee for Hydraulic Studies (CIER). These studies provide the base for rational development of water resources in the Savanna region of West and Central Africa. The reports include a synthesis of existing information on water, land and human resources, reviews of current water use, land cover/use studies and an analysis of future water requirements. This set constitutes a valuable addition to

the collection. Another acquisition of note was also a gift and was received from linkage with the Great Britain Ministry of Overseas Development, Land Resources Development Center. This set also consists of seven volumes entitled, Land Resources of Central Nigeria. Agricultural Development Possibilities, 1978. The work consists of maps, plans, proposals relating to land use, agricultural systems, range management, forestry, mechanization, conservation practices, crop adaptation and soil classification. It should be noted that linkages such as these and the document exchanges established provide the cooperation, awareness and collaborations that strengthen international ties. The Information Center has likewise received a tremendous response to the offering and availability of its publications.

New associations were developed during the reporting year such as the TOOL (Technische Ontwikkeling Ontwikkelingslanden) Foundation for Technical Development with Developing Countries in the Netherlands. TOOL is a cooperative body, composed of nine member groups with several hundred members. A basic activity is the technical inquiry service which responds to questions on agriculture, small-scale water supplies, housing, health care, small-scale manufacturing, information and organization. Connected to this service are several expert panels of research personnel working on topics for publication or development as projects for solar-powered ice-making devices. Since one of their emphases is the international exchange of documents, our Information Center is a natural linkage.

Another new association has been with the International Institute

for Land Reclamation and Improvement (ILRI) in the Netherlands. Again this linkage is applicable since the organization deals with research and projects worldwide on irrigation and drainage.

As a result of an article about our project and services appearing in the April, 1979 issue of IRRINEWS (publication of the International Irrigation Center in Israel) we received numerous inquiries, contacts and associations with various organizations. One such contact was from the Roseworthy Agricultural College in South Australia. The college offers a graduate diploma in Agriculture developed specifically for the training of graduates from the Middle East-North Africa region in dryland farming systems. The course is provided under contract from the FAO and has been in operation for four years. The course teaches practical farm operations and deals with the areas of cereal agronomy, pasture management, farming systems and management, farm mechanization and field experimentation. Our project was able to provide some references.

Contacts and associations achieved through visitor programs were remarkably productive. Adli Bishay, Director of the Desert Development Demonstration and Training Program with the American University in Cairo spent the day with project staff, faculty and at the Information Center reviewing potential linkages, cooperation and exchanges for his program. The program was initiated in 1979 and is based on the establishment of a demonstration project in a newly reclaimed desert area, with various approaches and alternatives to development of integrated desert communities. The ultimate goal is to establish different patterns of desert development as alternatives for what could be done in larger scale programs. The project is concerned with arid lands technologies

appropriate for Egypt's climate, physical, human and capital resources, its environmental concerns and socioeconomic and traditional patterns. Thus optimum land and water resources management is a major goal. The project will also be directed at the establishment of small scale agriculturally based industries, the production of solar, wind and biomass energy for rural communities and the design of energy efficient low-cost housing for hot, arid environments. The American University in Cairo is establishing cooperation with universities and research institutions worldwide with the aim of providing research, training and demonstration of arid lands agriculture in an interdisciplinary program not presently available in any local institution. We were pleased to be contacted in regard to this cooperation.

The National Academy of Sciences, National Research Council in Washington, D.C. through their visitor program initiated another valuable association through Dr. Ahmed Bakr, Faculty of Agriculture, Cairo University. Dr. Bakr is connected with the "More and Better Food" project for the Applied Science and Technology Program of the U.S. with Egypt. It is designed to improve institutional capabilities of the Egyptian scientific and technical community in developing and managing research programs dealing with priority needs of Egypt. AID is assisting the Egyptian Academy of Scientific Research and Technology (ASRT) and the U.S. counterpart organizations are the National Science Foundation (NSF) and the National Academy of Sciences. Dr. Bakr visited UCR and specifically the Departments of Soil & Environmental Sciences, Botany and Plant Sciences, the project and information center

and the U.S. Salinity Laboratory. It was a welcome opportunity to forge new ties with international scientists.

Another opportunity which forged international linkage and communication was the visit of a China scientific delegation to UCR. This visit was initiated as a result of a previous visit sponsored by the National Geographic Society of a U.S. group to China, July-August 1979. The scientific exchanges occurred with the Chinese Institutes of Geography and Desert Research (Academia Sinica) and one of our graduate students, Bob Ford, who was a member of the team which traveled to China. Chinese scientists were aware of the work at UCR and Bob Ford delivered numerous materials and publications from our project. The Chinese delegation has since visited UCR and was extremely interested in student exchange programs and the level of courses and resources in agriculture. They are particularly involved in arid land agricultural research, ecology, desert reclamation and remote sensing. Cooperative research ties have been strengthened and there will be a continuing exchange with researches and document exchanges as well. They are also interested in long term cooperative research projects for which UCR is well suited. The group reviewed our documentation and met with all applicable departments and viewed field site interests in Imperial Valley, the California Water Project, the U.S. Salinity Lab and areas of the Mohave Desert. We all look forward to this budding relationship and the opportunities for exchanges.

The Information Center computerized data base services have been extensively utilized for all types of inquiries from individual projects to country program literature searches. There has been a predictable

yet significant increase in the number of graduate students enlisting our information services and the large number of project-related research areas being explored. In addition to assisting in reference, bibliographic, information services the Center has been regularly consulted on documentation organization, systems and design for application into other major international agriculture programs. Some of the requests for assistance are a result of the Title XII programs and specialized grant projects throughout the U.S. Examples of these requests include the Niger Cereals Project, International Center for Arid and Semi-Arid Land Studies (ICASALS) in Lubbock, Texas; the Farming Systems R & D Methodology Project, Utah State University, Dept. of Agricultural and Irrigation Engineering at Logan, Utah; the Water Resources Research Center of the University of Arizona at Tucson; the National Water Well Association at Worthington, Ohio; the Bean/Cowpea Planning Program, Michigan State University in East Lansing; the Industrial and Technical Referral Center, University of Missouri-Columbia; the Plant/Resources Institute in Salt Lake City, Utah and the College of Agriculture at Montana State University in Bozeman.

#### Bibliography for Objective/Output No. 2

- Illes, Doris. Resource Directory for Agricultural Research in Semi-Arid Regions. Boston, G. K. Hall, c1979.
- Current Agricultural Research Information System (CARIS). Directory of Agricultural Research Institutions and Projects in West Africa. Rome, FAO, 1973.

A.I.D. A Directory of Institutional Resources Supported by Section 211(d) Grants - U.S. Centers of Competence for International Development.  
January, 1975.

African-American Institute. African Colleges and Universities: A Digest of Information, New York, 1970.

**C. Objective/Output No. 3: Improved Research Capability and Increased Knowledge Base**

**1. Narrative Description**

During the last year of the project, progress toward fulfilling this objective on increasing the research capabilities and improving the knowledge base of a cadre of faculty was complete. Six of eight graduate students had completed theses (4 Ph.D. and 2 M.S.) and two other Ph.D. candidates were in the process of finalizing their theses. Eight faculty were involved as major faculty advisors and several others were involved in committees and with assistance to students in the direction of research.

In addition to these faculty being directly involved in research, of which a large part was field research, fourteen others were authors on chapters in the state of the art publication. Several other faculty were involved in development activities in IDCs in exchange programs, design and analysis of projects and project development. The research knowledge base was also increased by several exchange scientists doing research on campus from semi-arid regions and several graduate students from these countries on non-211(d) grant support.

Cowpea (Vigna unguiculata (L) Welp) was selected early in the research program as a crop in which the faculty could have the most impact in semi-arid regions in crop production. Cowpea is a supplementary crop

to millet in the drier areas and sorghum and maize in the medium to wet regions. A minimum of research on cowpea in the dry regions of the semi-arid tropics has been conducted relative to crop production and soil and moisture conservation. With this in mind and with California being a large producer of cowpeas (dry or mature pea), a research program covering a broad area using cowpea as a crop was devised. This included breeding for drought resistance, nitrogen fixation, root development and soil physical properties, growth and yield characteristics under soil moisture stress and other studies on the physiology of cowpea (See Appendix V — Summary Research Report).

A means of verifying progress and ultimately in completion of the objectives for improved research capability and increased knowledge in semi-arid regions lies in the accomplishments: a) number of faculty trained and their research areas, b) publications of this research, c) completion of the state of the art and its effective use, d) a semi-arid agricultural production program with adequate course structure that is attracting developing country graduate students and other foreign students, e) faculty use in international development, international seminars and meetings and other activities related to the program. There is necessarily some overlap in accomplishments with other objective/outputs.

## 2. Targets for the Reporting Year

- a. To complete the State of the Art Review and submit it to the publisher.
- b. To continue research problems on cowpeas identified and implemented

in the fourth year, and to begin some new studies relating to cowpea production.

- c. To complete graduate research projects and those being conducted by faculty.
- d. Publication of results.

The magnitude of accomplishment expected from the research studies are the beginning steps of what will be a major part of the project's long term work in the developing countries. The State of the Art review is expected to be completed and published during the final year. This should establish the faculty to assist development in semi-arid tropic countries.

Assumptions critical to the success of these targets were:

- 1) that the Information Resources Team would be able to assemble in usable form the bulk of published and report material essential for the State of the Art review;
- 2) that practical and feasible research problems whose solutions are likely to make a real impact on the overall problem would become evident in the course of making the State of the Art review and in team program efforts.

The means of verifying progress made in this category would be the completion of projects both on-campus and in the Sahel, and completion of the State of the Art review and other publications. However, on-site visitation, discussion with appropriate staff members, and the Annual Report, coupled with various in-house reports give evidence of progress.

### 3. Accomplishments

a. Accumulative--the reporting year is the fifth and final year of the grant. Accumulative accomplishments based on program activities throughout the project will be reflected in the completion of projects.

1. The Research Team used information gained in the literature review, visits with foreign country scientists, and a methodology approach to graduate student training in field research for planning field programs that centered on cowpeas (Vigna unguiculata L.). Two projects were planned and initiated on the UCR campus in the third year under the topic title "Research and Training in Crop Response to Water and Evaluating Drought Resistance". The projects entitled "Evaluating drought resistance of cowpeas", and "Soil water use, evapotranspiration and root development of cowpeas under varying stress" are continuing. Some of the field studies were repeated during the summer of the fourth year. A study to determine vigor and efficiency of cowpea root systems initiated in the third year in greenhouse and field studies is continuing and a new greenhouse study on root systems and soil barriers started in the fourth year was completed. (See Publications Appendix V.)

2. During the team trip into France and West Africa, discussion focused on cooperative projects with French researchers and ministers of agriculture and development in Mali, Senegal and Upper Volta, with IITA in Nigeria, and with IAR in Nigeria. From these discussions and those later with the Program Director, two cooperative projects were planned and initiated; these are entitled "Perception and management of semi-arid indigenous agricultural systems", and "Quantitative analysis of

dryland farming systems in semi-arid regions of Africa", and were located in Upper Volta and Senegal respectively. The study in Upper Volta was completed in December 1977 and the data from this study is now being processed into publications and a Ph.D. thesis. For background on this study see Appendix V. The project in Senegal was continued through the grant and resulted in a publication on fallow-farming systems using a model to simulate the hydrologic budget (see Appendix V).

3. Various types of exchange projects were continued during the last year of the grant. Among these was the exchange faculty-researcher project with ORSTOM at Dakar, Senegal. This has broadened the knowledge base of both groups in basic and applied research.

#### b. Reporting Year

1. Cooperative planning was continued with Senegal through ISRA and CNRA-Bambey. A cooperative project (part of the Cooperative Research Support Program (CRSP) on beans and cowpeas) with CNRA-Bambey will be implemented when funds are allocated for the project. This will be a breeding-cowpeas production project with CNRA-Bambey and conducted by Dr. A. E. Hall one of the faculty trained in the grant. A project on beans with Kenya will be conducted by Dr. G. Wainee, also a faculty member that was involved in the 211(d) grant program.

2. The faculty-scientist exchange program with ORSTOM was expanded to include an 18 mo. visit at UCR by Mr. Jean-Claude Prot, Nematologist with ORSTOM at Dakar. He worked on nematode research in semi-arid conditions with nematology faculty at UCR. Dr. Reinhold Mankau, Nematologist at UCR spent a year at the ORSTOM laboratories in Dakar and collected nematode

specimens in various parts of West Africa. A spin-off from this program has resulted in other scientists from the developing countries wanting to continue research studies in nematology at Riverside. At present a nematologist from Nigeria is spending a year at UCR to further his knowledge in nematode research for West Africa.

3. The cowpea research was continued during the last year of the grant and when the CRSP cowpea project is funded will continue to be a strong link with Senegal and other semi-arid countries. (See Appendix V for publications concerned with cowpea research).

#### D. Objective/Output No. 4: Increased Advisory Capacity

1. Narrative Description - Advisory functions were defined by the Educational Training and Advisory Team to include problem identification and analysis, program or Project design, and Project operation, which may include education, training, research, technical services, and evaluation. The Educational Training and Advisory Team worked closely with the Information Resources Team, and in this reporting period requests for information were always accommodated. It is expected that as the research competence in the area of semi-arid tropical zone agriculture grows, and as the UCR faculty become known as a talent pool for this region, agencies in the developing countries and elsewhere will call upon this project for advisory purposes and this has happened several times.

Another aspect of advisory capacity is the training of personnel on this campus. Much of the previous years was spent in orientation of the

Project team members and other affiliated personnel on-campus to conditions and problems of the Sahel region and of the semi-arid tropical areas in general. In the past five years several seminars and lectures have been held, films have been shown, general reading suggested, and visiting professors and post-doctorals have added to the training. These activities are largely introductory in nature, outlining to those attending the various aspects either of agriculture in the semi-arid tropics, or specific conditions and problems of the Sahel area. Projects in the Sahel and visits to these and other areas by several faculty have increased the knowledge base on problems in the semi-arid tropic regions.

Training of Project personnel also has included instruction in the French language, beginning with a crash course for the travel team which went to West Africa in the first year. Graduate students who intend to pursue research overseas, and all Project staff, are encouraged to work toward verbal and reading ability in French. Teaching materials in the form of the Living Language cassette tape and book system were purchased and a collection of French-African agricultural materials is being accumulated.

## 2. Targets for the Reporting Year

- a) Completion of faculty-exchange programs.
- b) Involve faculty in projects where advisory capacity could be increased.

Magnitude of progress toward reaching these targets is necessarily low because of the nature of the targets and the individual faculty time that can be assigned to the program. As was intended, beginning and

preliminary steps in these directions have been taken, with maturing of the efforts to take place at later stages of the program.

An assumption critical to the fulfillment of these targets is:

- 1) that developing countries and organizations working in these regions will in fact seek out and accept advice from UCR.

Means of verifying progress made toward these targets could include evidence of the programs held and requests fulfilled, as indicated in in-house reports and records, as well as the Annual Report.

### 3. Accomplishments

a. Accumulative - The reporting year is the fifth year of the Project and accumulative accomplishments include: seminars, lectures, film programs and informal meetings with visitors recorded below.

2 December 1974 - Mr. Volney M. Douglas, Range Ecologist, Seminar: "An Ecologist's View of the Sahel".

5 December 1974 - D. Wynne Thorne, Vice President for Research and Director of Utah State University Experiment Station, Seminar: "Research Programs of International Crops Research Institute for Semi-Arid Tropics".

2 May 1975 - Bert A. Krantz, Agronomist, ICRISAT, Hyderabad, India, Seminar: "Farming Systems Research for the Semi-Arid Tropics of the World".

27 May 1975 - Film: The Bend of the Niger.

25 May 1975 - Films: The Fulbe of M'Bantou; Maninka Villages; Trade and Markets in West Africa; and short anthropological films.

- 13 August 1975 - Captain Sekou Ly, Major of Bamako, Mali. Informal seminar with Project members and other faculty of the Soil & Environmental Sciences and Botany & Plant Sciences departments.
- 8 September 1975 - Josephine Guissou, Rural Sociologist of the Societe Africaine d'Etudes et de Developpement (SAED), Ouagadougou, Upper Volta: Informal seminar with Project members and faculty of the departments of Social Sciences, Botany & Plant Sciences, Anthropology, and Black Studies and the Women's Resource Center.
- 24 September 1975 - Dr. William O. Pruitt, Water Science & Engineering, UC Davis, Seminar: "Predicting Crop Water Requirements—Worldwide and Southern California".
- 23 October 1975 - Dr. E. A. Hurd, Senior Research Scientist, Agriculture, Saskatchewan, Canada: Slides and lecture-seminar on "Agriculture in East Africa".
- 17 February 1976 - Dr. Howard M. Taylor, USDA-ARS, Iowa State University, Seminar: "Soil moisture utilization in semi-arid tropics from summer rainfall".
- 15 April 1976 - John Buursink, CIEN, Ouagadougou, Upper Volta: visited Information Center and met with Project members.
- 17-19 June 1976 - Soumana Traore, Director of SAED, Ouagadougou, Upper Volta. Met with Project members, consulted Information Center, visited drip irrigation projects, groves, chicken ranches and vegetable production areas.
- 3 May 1976 - John Pearson of Cal Poly Pomona: consulted Information Center.
- 3 May 1976 - Charles Rosenberg, Giannini Foundation, UC Berkeley: consulted Information Center.

- 15 May 1976 - Al Levinson, Giannini Foundation, UC Berkeley: consulted Information Center.
- 27 July 1976 - Peter Falke, Dept. of Botany & Plant Pathology, Michigan State University, Seminar: "The Potential of Leguminous Trees for Food Sources in Semi-Arid Countries".
- 21 November - 3 December 1976 - Dr. J. F. Poulain, IRAT, Upper Volta visited and consulted the Information Center collection at length. He donated many valuable research papers and documents to the collection.
- 3 December 1976 - Dr. J. F. Poulain, Agronomist, IRAT, Upper Volta, Seminar: "Overview of French Research in the Sahel-Sudan Zone".
- 9 December 1976 - Dr. J. F. Poulain, Agronomist, IRAT, Upper Volta, Seminar: "Soil Fertility Studies in Crop Production in the Sahelian-Sudano Zone of West Africa".
- 16 December 1976 - Dr. J. F. Poulain, Agronomist, IRAT, Upper Volta, Seminar: "A Systems Approach to Soil Mapping and Agronomy".
- 6 January 1977 - Mr. Fred R. Weber, Consulting Engineer, International Resources Development and Conservation Services, Boise, Idaho, Seminar: "Physical and Cultural Constraints of Irrigation in the Sahel".
- 15-16 January 1977 - Ms. Emily Candamo and Mr. Kisseiamba Ali of the Tippetts-Abbott-McCarthy-Stratton Agricultural Development Group for information regarding our resources and procedures. As a result the exchange of information has aided the work of TAMS to develop a major documentation center in Upper Volta for the Interafrican Committee for Hydraulic Studies.
- 3 March 1977 - Dr. Michel Luc, National Museum of Natural History of Paris, France: Seminar "Crop Protection in West Africa".

- 14 March 1977 - Dr. A. E. Hall, UCR Department of Botany & Plant Sciences,  
Seminar: "Improving the stability of crop production in semi-arid West Africa".
- 28 April 1977 - Dr. Michel Luc, National Museum of Natural History, Paris, France. Seminar: "Nematode Problems in West Africa".
- 22-23 April 1977 - Dr. Gora Baye, Centre National de Recherches Agronomiques (CNRA) in Senegal, attended Project Symposium, met with researchers and consulted Information Center.
- 15 June 1977 - Koko Dembele, Governor, Region of Gao, Mali; consulted Information Center and expressed a desire to participate in document exchange program.
- 25 June 1977 - Mrs. Janina H. Bard, International Irrigation Information Center, Volcani Center, Israel, consulted Information Center.
- 20 October 1977 - Mr. Peter Shouse, graduate student in the UCR Department of Soil & Environmental Sciences. Seminar: "The Effects of Systematic Water Deficits on Blackeye Peas".
- 27 October 1977 - Mr. Robert Zablutowicz, graduate student in the UCR Soil & Environmental Sciences department. Seminar: "Field study of nodulation in California-grown cowpeas".
- 7 November 1977 - Mr. David Gipson, graduate student in the UCR department of Soil & Environmental Sciences. Seminar: "Interaction between salinity and plant roots".
- 28 November 1977 - Mr. Peter Shouse, graduate student in UCR's department of Soil & Environmental Sciences. Seminar: "Field studies of chemical transport".

- 15 November 1977 - Mr. Peter Shouse, graduate student, UCR Department of Soil & Environmental Sciences. Seminar: "Effect of Systematic Water Deficits on Yield of Blackeyed Peas", at the American Society of Agronomy meeting in Los Angeles, California.
- 17 November 1977 - Mr. Robert Zablutowicz, graduate student, UCR Department of Soil & Environmental Sciences. Seminar: "Field Study of Nodulation in California-grown Cowpeas under Normal and Drought Conditions" at the American Society of Agronomy meeting in Los Angeles, California.
- 7 December 1977 - Mr. Koly Kourouma, Director of Division of Exact Sciences, National Institute of Documentation and Scientific Research, Conakry, Guinea, consulted Information Center and toured campus citrus groves and field activities.
- 26 January 1978 - M. Yves Demare of ORSTOM, Dakar, Senegal - Seminar: "Effects of soil temperature and moisture on nematodes in the root zone".
- 9 February 1978 - Mr. Sekou Sissoko, Director of Agriculture, Ministry of Rural Development in Mali, visited Information Center and discussed campus research activities and information exchange.
- April-June 1978 - Mr. Moctar Toure of the Institut Senegalais de Recherches Agricoles (ISRA), Rice Research Station of Djibelor, Senegal, consulted the Information Center collection at length.
- 30 May 1978 - M. Yves Demare of ORSTOM, Dakar, Senegal. Seminar: "Anhydrobionis in nematodes".
- 20 June 1978 - Marion DeBoeu of the World Health Organization (WHO) in Switzerland, consulted Information Center.

- 28 June 1978 - Dr. D. P. Taylor, Head of Hematology Laboratory, ORSTOM, Dakar, Senegal, consulted Information Center and met with Project Director.
- 1 August 1978 - Michael Carr of the National College of Agricultural Engineering, Bedford, England visited the Information Center and consulted sources relating to his project, "Crops & Irrigation".
- 11 August 1978 - Dr. Antonio G. Santos of the Instituto Universitario de Evora in Portugal visited the Information Center to obtain all available information relating to dryland farming under rainfed conditions, erosion control systems and drainage.
- 17 September 1978 - Nasser O. Al-Saleh of the Saudi Arabian Ministry of Agriculture and Water visited the Information Center.
- 20 November 1978 - Eric Morris from the Agriculture Dept., LLU-LSC obtained references on forage crops (especially millet).
- 3 April - 20 April 1979 - Barbara Heinsen of the Niger Range & Livestock Project consulted the Information Center and UCR Libraries to identify, cite and obtain relevant materials relating to Niger for the establishment of a resource center for researchers.
- 26 June 1979 - Dr. Bruce C. Imrie and Don Beech of CSIRO Division of Tropical Crops & Pastures, Cunningham Laboratory in Brisbane, Australia consulted the collection for materials/bibliography on cowpeas with the aspects of temperature conditions and plant breeding.
- 28 June 1979 - John A. Mhville, Regional Commissioner and Yusuf H. Nabalang'anya, Member of Parliament & National Executive Committee of Tanzania visited the Information Center. They are agricultural

policy developers and were interested in major crop information at the small farmer level.

17 Jul, '79 - Dr. A. S. El-Beltagy, Faculty of Agriculture, Ain Shams University in Egypt visited the project as representative of the Executive Committee for "New Crops for Arid and Semi-Arid Zones" project in Egypt. Information was compiled and materials will be exchanged.

14 August 1978 - David Giles, agronomist for Hunting Technical Services, Buxhamwood, England consulted the collection for information on crop growing and research done in the U.S. He had spent the previous 1-1/2 yrs. in Iraq.

### TRAVEL

May 1978 - May 1979

July 18,19,20 (1978)	Glen H. Cannell	Newport, Oregon - CID Annual Board of Trustees Meeting
Aug. 7,8,9,10 (1978)	Yves Demours	Hot Springs, Arkansas - Present paper Society of Nematologists Annual Meetings
Oct. 4,5 Nov. 24,25 Dec. 27, 28(1978) Jan. 24,25,26,27, 28 Feb. 27,28 Mar. 1,2,3,4,5, 6,7,8,9(1979)	Reinhold Munkes	Senegal and Mali, West Africa - Soil Collection, agricultural field trips in Senegal; visit USAID "Operation Mil" Bamako, Mali and deliver lecture to local agricultural extension agents there.
Oct. 28,29,30, 31 Nov. 1,2, 3,4(1978)	Doris Illies	To view and discuss current information handling systems in Washington, D.C. To participate in African Studies Ass'n. Meetings in Baltimore, Md.

**TRAVEL, cont'd.**  
**May 1978 - May 1979**

Dec.14,15(1978)	Glen H. Cannell	Berkeley, Ca - Title XII Beans/Cowpeas Collaborative Research Support Program discussion
Jan.24(1979)	Anthony E. Hall	San Jose, Ca - Visit with MUSAT:era grad students; confer with Program Director on research projects, planning
Jan.25,26,27 (1979)	Glen H. Cannell	Washington, D.C. - Discuss time extension of AID 211(d) grant; present Information Center Project proposal
Feb.2,3,4,5, 6(1979)	Glen H. Cannell	New Orleans, La - Title XII Cowpea CRSP Meeting in New Orleans; intermediary stop at Univ. of Arizona to discuss cowpea proposals
Mar.3(1979)	Glen H. Cannell	Cal Poly, Pomona, Ca - Meetings with Cal Poly, CID, AID and a team from Kenya on a project at Edgerton College
Apr.2,3(1979)	Glen H. Cannell	Cal Poly, Pomona, Ca - Workshop on strengthening grants held at Cal Poly, Pomona
May 28,29,30, 31 June 1, 2,3,4,5,6, 7,8,9,10, 11,12,13,14, 15,16(1979)	Jean Claude Prot	Visit Dept. of Plant Pathology at Cornell, North Carolina State Univ., Univ. of Florida, Louisiana State Univ. USDA Nematology Lab, Beltsville, OTAN Meeting, Charleston
May 19, June 13 (1979)	Glen H. Cannell	Team Leader for bean/cowpea - CRSP visits to Kenya, Tanzania, Malawi, Botswana, Zaire and Nigeria
Oct. 1980	Anthony E. Hall G. Wainee	Bean/cowpea - CRSP visits to Senegal and Kenya

Through this part of the program the program staff has had the opportunity to learn of the research being conducted at various international centers within the West African countries and to see a vivid picture of the problems concerned with semi-arid regions. The State Department's International Visitor List has been helpful in locating visitors from the Sahel who have considerable relevance to the program. These visitors have participated in an informal lecture/question-answer type of program and have thus provided a broad spectrum of the problems and living conditions in the Sahel.

Introduction to French conversational language courses for the travel team into West Africa included the Living Language French course, extracts of French texts on agronomy and related activities, and manuscripts acquired from IRAT and ORSTOM. Tutors and the opportunity to attend specialized French language training are made available to faculty and staff.

The team travel into France and West Africa during the second program year proved to be a very worthwhile experience for increasing the knowledge base, establishing worldwide linkages, developing project ideas, and learning first hand the agricultural and educational problems facing the Sahel countries.

Perhaps the most appealing aspect of this travel has been the encouraging, cooperative attitude of the French headquarters staff in Paris, their researchers in West Africa, the Ministers of Agriculture and Development of the Sahel countries, IITA, and the USAID Mission staff in Senegal and Upper Volta.

The following programs, originated in the second year of the program and implemented in the third year, indicate the linkage support previously mentioned, and give the project a strong base for improving and increasing the Advisory Capacity:

1. Two exchange-type projects were arranged with IRAT and ORSTOM. The first brought Dr. F. Poulain, an Agronomist of IRAT-Upper Volta, to the UCR campus in November 1977. He presented a series of seminars on soil fertility studies in the semi-arid tropics and the material presented will be published as part of the cooperative project. The second exchange-type program involved Dr. M. Luc, ORSTOM, Museum National d'Histoire Naturelle, Laboratoire de Zoologie, Paris. A nematologist, Dr. Luc has spent many years in West Africa and is head of the Nematology and Microbiology overseas section of ORSTOM. He spent a six-month sabbatical leave at Riverside, providing a teaching element and an information base on nematology in the semi-arid West Africa region. M. Yves Demeure, ORSTOM Dakar, Senegal spent one year, 1977-78, at UCR working with effects of soil moisture and temperature on nematodes in the root zone. He was followed by Mr. Jean-Claude Prot working on similar research for an 18 month stay. The significance of the latter two in addition to the excellent exchange of knowledge is that both completed the research requirements to satisfy the Ph.D. equivalent requirements in the French education system.

2. "An International Symposium on Rainfed Agriculture in Semi-Arid Regions" was jointly sponsored by UCR and Oregon State University and the Consortium of Arid Lands Institutes (CALI). UCR was responsible for the

semi-arid tropics with summer rainfall, OSU for the mediterranean-type regions with winter rainfall, and CALI in a supporting role. The Symposium was held April 17-22, 1977 in facilities adjacent to the UCR campus and included some activities on-campus and a two-day field trip in Southern California. Over a thousand copies of this publication have been distributed throughout the world and requests for copies are continually being filled. (See Appendix V - publications for requesting this publication - 100 or so copies are still available.)

3. Slide sets and other audio-visual materials are being compiled of material taken during various trips to West Africa and these have been duplicated, recorded and arranged to provide the basis for lectures and other presentations. Film catalogs were collected and lists of films dealing with semi-arid tropic regions were compiled from these materials. Several films were shown on campus at lunch brown bag sessions.

4. Miss Claire Hill, a former UCR student and a graduate student at a University in Paris, France, worked as a translator for the MUSATERS program, working part time translating needed materials for various projects, assisting with the Information Center collection of materials and maps, and assisting staff members on particular problems involving projects in Upper Volta and Senegal. She worked closely with ORSTOM staff on translation of their papers for the Symposium. Having Miss Hill as a contact in Paris was particularly valuable to the program since much of the research literature on West Africa is written in French and is located in libraries and research centers in France.

## b. Reporting Year

The worldwide linkages previously established that relate to program advisory activities were strengthened with exchange of information, visits to various areas for program planning, presentation of materials at national and international meetings of material developed at UCR and in the developing country projects, the scientist exchange program and other activities. These are summarized as follows:

1. In June, 1978, G. H. Cannell and A. E. Hall met with Dr. L. Sauger, ISRA; Dr. P. Goldworthy, IITA; Dr. P. L. Stoponkus, Cornell University and Dr. J. L. Boyer, Boyce Thompson Institute, Cornell University at Dakar, Senegal. A proposed 5-year project on cowpeas was developed and copies sent to each cooperator and the U.S. AID Mission in Dakar. Action was never developed on this proposed project, titled "Development of Improved Cowpea Varieties and Improved Management for Semi-Arid Environments".

2. Cooperative plans previously arranged with ORSTOM and the UCR Department of Nematology were completed and Jean-Claude Prot, ORSTOM Laboratories at Dakar spent 18 months working at UCR on nematology problems related to semi-arid soils. Dr. Reinhold Mankau, nematologist, UCR spent 1 year July 1979-80 at ORSTOM in Dakar, Senegal.

3. In cooperative development with Michigan State University (MSU), planning agent for the Title IX Bean/Cowpea - CRSP, G. H. Cannell, Team Leader for a 3 person team visited Kenya, Tanzania, Malawi, Botswana, Zaire, and Nigeria to evaluate Bean/Cowpea production in these regions and to assess possible cooperative programs based on need and constraints within the total region. This report is included in Appendix V since it contains useful information and a number of contacts in the region.

4. G. H. Cannell attended two planning meetings with Michigan State University on the Bean/Cowpea - CRSP. These meetings eventually resulted in having Senegal placed on the list of countries where cowpea crop production research could be carried out and the information used on a large regional basis.

5. In response to MSU's call for projects, UCR put together a comprehensive proposal from 15 faculty. Most of this group was involved in the AID 211(d) grant. This approach was not accepted by MSU as not meeting the 'complement supplement' objectives of the CRSP. However, our faculty continued to work with MSU with the CRSP. A. E. Hall and G. Waines made team trips to Senegal and Kenya in October 1978, respectively, to cooperate in planning for CRSP projects in these two countries. In the final plan presented to BIFAD a project was to be initiated in cowpea breeding for drought resistance in Senegal by A. E. Hall and a somewhat similar project on beans by G. Waines in Kenya.

6. A microfiche information delivery system proposal was prepared using CIDNET as an information data base. The proposal was accepted for consideration by AID-DS/DIV/DI but because of changes in their objectives the proposal was tabled to be presented to other organizations. No specific action has been taken on the proposal.

7. An extension of one-year funding for the Information Center was made in a proposal to AID-DS/DIV/DI. Funding is expected for this proposal.

8. The State of the Art review on Agriculture in Semi-Arid Environments was published by Springer-Verlag and Co. in September 1979. This is part of their Ecological Studies Series (see Publications, Appendix V).

9. A film of the MUSAT:era program, entitled "New Directions in Dryland Farming", was completed by the International Communication Agency (ICA) in the summer of 1978. ICA (formerly U.S. Information Agency) has produced the film in English and French and it is now available for showing in the developing countries. A good part of the film centers on cowpea field research being conducted as part of the MUSAT:era program. In particular, it shows how U.S. universities can fit into a research program that is adaptable to the developing countries. Much of the data obtained from the applied field research conducted at UCR is adaptable to the semi-arid tropic regions because of the hot, dry summers of the UCR area, and this allows use of a simulation technique of sprinkler irrigation to study plant growth and fruiting characteristics under various soil-water conditions. Because of the equipment, facilities and research personnel available at U.S. universities, basic research relative to production problems in the developing countries can be carried out simultaneously with the field research.

#### **E. Objective/Output No. 5: Educational Capabilities in Dryland Moisture Conservation and Utilization**

##### **1. Narrative Description**

At an early meeting of the Curriculum Development Team, a core of curriculum courses already offered at UCR which deal with problems related to the Project, or which could be modified to fit into Project-related areas, was itemized. Two new courses have been added to this list: an

introduction to soil science, and a field study of California soils, mapping and classification, in cooperation with the University of California at Davis.

Soil Science 100	Introduction to Soil Science
Soil Science 104	Soil Chemistry
Soil Science 105	Summer Field Course
Soil Science 107	Soil Physics
Soil Science 111	Soil Microbiology and Biochemistry
Soil Science 118	Soil Morphology
Soil Science 103	Soil Fertility
Soil Science 206 (A & B)	Principles and Theories Relating to Arid Zone Soils
Soil Science 208	Soil Physical Conditions & Plant Growth
Plant Science 103	Ecology of Crop Plants
Plant Science 104	Physiology of Crop Plants
Plant Science 120	Grasses & Grasslands
Plant Breeding 150	Plant Breeding

Discussion has been underway for the possible addition of new courses to the present curriculum, or the presentation of special topics within existing course structures, in order to widen the education element of the Project. Care is being taken in planning so that such courses would be appropriate to UCR's overall program goals and would fit in with University-wide curriculum planning. General topics of new courses or modifications of existing courses are:

1. irrigation and drainage
2. soil management, with emphasis on field crops
3. agricultural resources development
4. field crop production (cereals, legumes, oil seed crops)
5. field plot design (enlargement of Plant Sciences 149)

Several graduate students began their studies in Project-related research topics during the second and third years of the grant; no new students were selected for graduate studies during the fourth year because of the time limit in finishing the graduate degree before the grant ends during the fifth year.

## 2. Targets for the Reporting Year

a. To encourage the graduate students that were accepted into the program during the second year to complete their research, present materials at society meetings, and to prepare materials for publication.

b. To continue expansion and modification of the course offerings at UCR to include course work related to agriculture in the semi-arid tropics.

c. To continue obtaining and evaluating curriculum information from other universities in the semi-arid dryland regions of the U.S. and in the developing countries. When faculty members visit areas where contacts can be made with universities or other institutions in the developing countries that relate to education training, information will be exchanged and encouragement given to consider the graduate program being developed at UCR for training their students.

The magnitude of fulfillment of these targets progressed satisfactorily: excellent graduate students with an international interest, and some with international experience were selected. Each student was guided in his research by an established faculty member with an interest in the project.

At this point only one new course has been established: "Modeling soil-plant atmospheres". Modifications of existing core courses or new courses to strengthen the existing ones have been made, and meetings involving the Departments of Botany & Plant Sciences and Soil & Environmental Sciences are continuing toward this goal. Information gathered from various U.S. universities (semi-arid zones) on course structure indicates that students interested in dryland agriculture are being served by core structure courses rather than by a separate curriculum; a report by one of our faculty who visited the University of Khartoum shows the same trend. Careful evaluation of courses and their value in training students from the developing countries is the desired target for the reporting year.

An assumption critical to the success of the targets is that increasing numbers of students both from the U.S. and the developing countries will be interested in graduate programs at UCR and the educational offerings that are relevant to dryland agriculture in low rainfall regions of the world.

Means of verifying progress made would include on-site visitation, and in-house reports as well as the Annual Reports and with increased enrollment in dryland agriculture.

### **3. Accomplishments**

a. The reporting year is the fifth of the Project. One new course, entitled "Modeling Soil-Plant-Atmosphere Systems" was developed in the second year of the grant and jointly offered as Plant Science 205 and Soil Science 205. In this course students conduct analyses on the computer with mathematical models programmed by the instructors on the quantitative treatment of water relations, temperature relations, and gaseous exchanges in soil-plant-atmosphere systems. Students develop and program their own mathematical models that are related to crop production in the semi-arid tropics.

The core of courses now available to graduate students and the experience gained through field research on cowpeas has given the MUSAT:era faculty a new dimension in training foreign students to fit into an applied research program on their return home. In the past foreign students have received basic training in research often not related to research needs in their home countries. A field research program will eliminate this negative aspect of graduate training which had been mentioned by visiting scientists from the developing countries.

#### **b. For the Reporting Year**

Of considerable importance in developing a curriculum for training students in dryland agriculture is the design of field courses that will give the student maximum exposure to practical problems. Discussion of team members has centered on approaches and methods, and some priority in development of the curriculum has been given to this aspect.

Specific courses have not been developed for field studies in training of students; for the design of experiments the general approach is obtained in courses in statistics and a field approach is provided in Plant Breeding 150. With these courses and field experiment design provided to the student by his advisor, a tested and satisfactory method of training students in experimental design has been developed. A good example of this is the M.S. thesis completed in the fall of 1976 by one of the students in the program entitled "Root growth of cowpeas as affected by soil physical properties and water stress". The student gained field experience in experimental design, soil physical properties and their measurement, experience in developing a root washing device and a root counting instrument, measurement of root lengths, soil root distribution and aeration and, finally, evaluating the factors related to root growth of cowpeas in a field situation involving several variables. This person is now working with a church organization in Upper Volta on a development project.

Each graduate student in the program is involved in a field research program and is gaining valuable experience in applied methods in crop production. This field research approach was incepted during the second year of the program. Research data from these studies and completion of theses and publications are being evaluated to determine its use as a model in curriculum development for foreign graduate students and future training in research for dryland farming.

It has been the contention of the Curriculum Development Team that key members of the faculty of Botany & Plant Sciences and Soil & Environmental Sciences should have the opportunity to visit other universities

in the U.S. and appropriate developing country universities that may have curricula that relate to MUSAT:era program objectives. Following written communication with universities in the semi-arid regions of the U.S., visits were made by faculty to several universities to discuss curriculum development. There were no prescribed curricula at these institutions that dealt directly with students interested in dryland agriculture; each university relied on their basic courses in soils, agronomy, plant sciences or other curriculum in areas to fulfill the needs of students.

A visit was made to the University of Dakar in connection with the Acacia albida State of the Art study as a follow-up to suggestions by the Director of CNRA in Senegal that some biological science students interested in graduate training may have an interest in an agricultural program at Riverside. There is some interest but nothing concrete has developed from this approach.

#### IV. IMPACT OF GRANT SUPPORTED ACTIVITIES IN ACHIEVING GRANT PURPOSES

##### A. Objective/Output No. 1: Central Information System

Bibliographic information resources are the backbone of research and educational activities. In order to support grant efforts in building institutional capacity for research and consultation, MUSAT:era has accumulated a large and comprehensive collection of material dealing with all facets of agriculture in the Sahel and in other semi-arid tropical regions. Members of the UCR academic community and visitors

to UCR have access to this collection through the indexes of the computerized bibliographic data base; access is supplied by subject, geographic area, author and title. Computer searches can be run to compile lists of material dealing with specific combinations of topics; for instance, insect pests of sorghum in West Africa. UCR users and area visitors can browse in the Project Information Center which houses the collection of reports, reprints and special maps. Other materials are available in the Campus Libraries.

The immediate evidence of the impact of the information system on grant purpose can be identified with the following:

- 1) Completion of the State of the Art on Agriculture in Semi-Arid Environments which has been published by Springer-Verlag & Co., c1979, and is Volume 34 of the Ecological Studies Series. This study involved eighteen faculty as authors, and three of these acted as editors. The Information Center was directly responsible for assembling information on the semi-arid regions for the authors. Most of this information was readily available from materials compiled during the first three years of the program, and supplemented by new material compiled during the reporting year.
- 2) The research program on cowpeas, participation by MUSATiere staff in the International Symposium on Rainfed Agriculture in Semi-Arid Regions, and publications related to the research.
- 3) MUSATiere publication by Gretchen Walsh covering the Geographical Index developed by the Information Center and published by G. K. Hall Publishing Co., c1977. The effect of the publication as a result of

its purchase and use on a worldwide basis has been a strong influence in developing worldwide linkages and in providing useful information to many organizations through the services provided by the Information Center.

4) MUSAT:era publication by program Librarian, Doris Illes, entitled: Resource Directory for Agricultural Research in Semi-Arid Regions, published by G. K. Hall, c1979. The Directory impacts on the grant purpose of promoting an extensive awareness and cooperation among individuals and organizations engaged in agricultural research projects worldwide. The work contains 1,500 citations for reference use. It is anticipated that additional contacts will result from this publication through referrals both national and international.

5) CIDNET. The development of this organization through the continued efforts of the MUSAT:era Director and the program Librarian in its development has provided a much broader based information base than the MUSAT:era Information Center can provide. The cooperative CIDNET resources comprise approximately 32,000 items with comprehensive subject and geographic coverage and specialties applicable worldwide. This added dimension can have a strong impact on many developing countries provided future funding can be obtained to continue CIDNET as a center to provide information to these countries. Proposed projects by MUSAT:era staff are being developed to make possible document delivery to the developing countries and to expand service potentials.

6) Statistical data accumulated in the Information Center. The number of requests for information, their origin, types of information

needed, organizations requesting information, outside visitors and local staff use of the Center are a direct indication of the impact on achieving great purpose (See Appendix I, II, III, and IV).

7) The development of the program's dryland agriculture collection has made possible the services of providing specialized and comprehensive bibliographies, computer searches and information packets. These unique and individually tailored services are supplied as appropriate and applicable to users' requests. The central information system also channels MUSAT's publications worldwide and exchanges materials with organizations through the National/International Cooperative Exchange system.

8) The growth of the Information Center is indicated by the number of entries. The entries are selected through cooperation with the MUSAT's staff in defining areas as well as valuable publications that fit into the objectives of the projects. The collection also has many research reports, symposium publications and many other materials not usually found in a general library. These, along with a significant map collection and scientific publications, comprise a collection at present of about 14,000 entries. With the CIDNET entries, a data base comprising 32,000 entries is available and completely searchable.

#### **B. Objective/Output No. 2: Network of Worldwide Linkages**

There is considerable interest in the United States and internationally in the problems and development potential of the semi-arid

tropics. The specific targets of the grant in this area are: developing cooperative liaison with governments and organizations and, where applicable, their parent organizations in the developed countries. The dual role of the Information Center and personal contacts with governments, organizations, institutions and other groups is an indicator of development of worldwide linkages.

A composite listing of the linkages is given in Appendix IV. The following are other indications of the impact of the grant in achieving the grant purpose:

1) Projects in developing countries. One project in Upper Volta, entitled "Management and Perception of Indigenous Agricultural Systems in a Semi-Arid Region of Northern Upper Volta", has been completed. This project has been used as a means for training of staff through visitation to the village sites and as an information source to plan future projects in the West African semi-arid tropics. A second project, entitled, "Quantitative Analysis of Dry-Farming Systems in Semi-Arid Regions of Africa" was undertaken in Senegal in 1976. This is a continuing project with research input being contributed by scientists from both Senegal and UCR.

2) Exchange scientist program with ORSTOM and the developing countries. A solid linkage with UCR has been established by this program which will be helpful in implementing needed projects in the semi-arid tropics of Africa. Reports, publications, and letters from ORSTOM headquarters indicate an impact from these activities on the grant purpose and their research programs in Africa.

3) International research centers, ICRISAT and IITA, have continued to be a part of the linkages developed early in the grant. Cooperation with ICRISAT in Upper Volta in 1977 on cowpea and sorghum plots, and with IITA on program planning with cowpeas, shows a continued interest by these organizations in a cooperative relationship with UCR in project design, information exchange, and project development and implementation in the semi-arid tropics.

4) Publication of the Directory entitled Resource Directory for Agricultural Research in Semi-Arid Regions. This publication provides an outlet for linkages with UCR and research scientists, research centers and organizations concerned with international development. The previous publication, a geographical bibliographic index entitled Moisture Utilization in Semi-Arid Tropics: summer rainfall agriculture (MUSAT:era) Project. A Bibliographic Data Base. . ., has had a worldwide impact on the purpose of the grant in developing linkages.

5) The National/International Cooperative Exchange Program has developed into a vital continuing linkage with organizations engaged in research and activities related to MUSAT:era objectives. Not only has the program gained valuable research publications free of charge to the collection, but the program has been able to directly disseminate research materials, reports, publications and referrals to interested groups worldwide. This is an active output of the improved and expanded knowledge base at UCR.

The linkages developed by contacts, and projects originating from these linkages, come closest to the underlying philosophy of the grant

purpose: to develop means of improving conditions in this area in a way that directly involves the people living there, that takes into account the reality of life there in its many facets, and does not simply present theoretical or technical recommendations which are in fact impractical and unacceptable.

The first three years of the grant paved the way for close and co-operative linkages, and many of these matured in the fourth year and have been continued in the reporting year. These linkages provide the basis for continual progress in all other program areas for future projects.

**G. Objective/Output No. 3: Improved Research Capability and  
Increased Knowledge Base**

Although each of the objective/outputs serves as a link in overall development of the grant purpose, the improvement and development of a core of program research staff that will be involved in projects in the semi-arid tropics is the key to reaching the grant purpose.

The selection of cowpeas as a major crop in which to build competence of the research staff for development purposes has proved to be a valuable training base. The breadth of cowpea projects related to the interests of the program staff have involved: soil-water-plant relations, symbiotic nitrogen fixation, cowpea breeding, cowpea root systems as a function of variety and soil conditions, modeling studies

related to plant growth and yield at Riverside and in Senegal, and nematology research.

The cowpea studies have been supplemented with information gained from the indigenous studies conducted in Upper Volta on farming systems and methods. Although the data from these studies have not been completely analyzed, information on planting dates, soils within the village areas where cowpeas are planted, insect and disease damage, and yields will be available. Visits by faculty to IITA and the project conducted in Senegal by A. E. Hall in 1977 as well as the project planning meeting on cowpeas held in Dakar, Senegal in 1978, and the faculty-scientist exchange project with ORSTOM have each contributed to building a strong research capability in semi-arid tropic crop production. The knowledge base developed is broad, comprehensive and although oriented to one crop cuts across several research disciplines.

The graduate students projects with field and basic research studies have greatly aided in the training of grant program staff. New approaches to field research have been gained from data obtained in the graduate programs and new projects which were undertaken during the fourth year from this source were completed.

The experience gained from the research projects has had a strong impact on the grant purpose. A research and development draft proposal prepared in June 1978 with representatives of the Senegal government and IITA as the major cooperators with UCR was made possible through research in Senegal, with IITA in Upper Volta and at UCR. IITA is located with ICRISAT in Upper Volta and is testing varieties in many areas of Upper

Volta and is testing varieties in many areas of Upper Volta under various rainfall and soil conditions.

Research publications, faculty and graduate student activities in presenting research data at society meetings, participation in the International Symposium on Rainfed Agriculture in Semi-Arid Regions held at Riverside, and completion of the State of the Art on Agriculture in Semi-Arid Environments attest to the impact of research on the grant purpose. (See Appendix V for publication list and accumulative activities Objective/ Output No. 4).

#### D. Objective/Output No. 4: Increased Advisory Capacity

Progress has been made in several directions in developing program staff in advisory capabilities. Program research staff and others have been provided opportunities with grant funds to learn about agricultural conditions in semi-arid tropic climates through travel, by attending and participating in international meetings, and by other activities in development programs. Reading lists, seminars, lectures, films, and special materials (made available through the Information Center) have provided a learning base for program staff concerning the semi-arid tropic regions.

The scientist exchange program developed in the second year of the grant with CRSTON and IRAT and developing country organizations has proved to be a fruitful means for increasing advisory capacity. The cooperative programs with Senegal and Upper Volta and with ICRIAT and IITA in those countries have provided program staff with advisory opportunities in developing countries.

Although the various methods described for increasing advisory capacity have been beneficial, the desired impact on the grant purpose of preparing scientists for advisory purposes were not completely met. The assumption was made in the grant that AID would provide opportunities for the program staff to attain experience through assignments in the developing countries, and thus improve their advisory capacity. Only two opportunities were provided and those only for the Grant Director, 1) representation of United States at CENTO meetings in Turkey 1976, and, 2) attend meetings in Central America and to assess semi-arid problems in Guatemala 1977. No other opportunities with teams that are sent to developing countries to assess problems and prepare reports was offered by AID to the 211(d) Grant faculty. However, grant funds were used for developing increased advisory capacity and this proved to be an effective means for meeting this purpose. A total of 14 faculty and 3 staff were supported from grant funds for implementing projects in developing countries, analyzing and assessing needs, developing linkages and proposals, determining education needs in international dryland agriculture and those available in the United States and developing information needs nationally and internationally. CID has offered opportunities for advisory development but mostly long term overseas, since our faculty was involved in grant projects and many outside our faculty expertise, none were accepted. CID will offer future opportunities and appropriate ones will be accepted by faculty.

The planning grant for the bi-national CRSP at Michigan State University (MSU) has offered opportunities for several of our faculty to

participate in assessing and analyzing production and constraints and program planning in various developing countries. Information on cowpeas was also supplied to the MSU planning grant by MUSAT:era library as well as a microfiche printout of the data base.

The faculty has offered to MSU their expertise in assisting with the State of the Art on cowpeas.

**E. Objective/Output No. 5: Education Capabilities in Dryland Moisture Conservation and Utilization**

With the addition of some new courses and revision of other courses in soil science and plant science, and with the development of field research studies, UCR is now in a position to train graduate students from semi-arid regions in agriculture. Since the grant does not support foreign students in graduate work at UCR the program has not had an opportunity to work with students from the dryland farming areas. This aspect will be developed in Title III projects.

The program staff, with experience gained in the field research studies, is prepared for special training of foreign scientists on short term assignments. Offers for this type of training have been made to Mali, Upper Volta and Senegal. Two scientists from CNRA-Bamby spent several weeks at UCR, however, the number of scientists in these areas is extremely limited and their positions are vital to their country programs. Arranging for a time when they can be at UCR for special training is difficult.

The curriculum as it is now constituted, including the field research program, is considered to be developed sufficiently for graduate training

of foreign students. The practical aspect of the program should be appealing to the governments of the developing countries, since this is the greatest need in implementing their agricultural programs. We believe the objectives for this part of the grant have been met and that the impact on grant purpose will be realized in future years.

The film entitled "New Directions in Dryland Farming", produced by U.S.I.A., now International Communication Agency (ICA) has had a positive impact in developing countries. Many letters have been received from persons in those regions after seeing the film requesting additional information on UCR, the dryland agriculture program and financial support. Funds for support of foreign graduate students in the University is usually not available--if funds could be made available a number of students could be trained at Riverside that would fit their countries needs and objectives.

#### **V. OTHER RESOURCES FOR GRANT-RELATED ACTIVITIES**

**See Section VIII, page 95 for use of other resources.**

## VI. UTILIZATION OF INSTITUTIONAL RESPONSE CAPABILITIES IN DEVELOPMENT PROGRAMS

### A. Requests for Assistance

Because of increased publicity of the Project, and because of the unique nature of the Information Center's collection and services, many requests for bibliographic and reference assistance were received during the reporting year. These requests covered a wide range of topics, and sometimes dealt with geographic areas outside of MUSAT:sra's scope. All requests were acted upon, however, and many were circulated among the CIDNET centers for further reference efforts.

In addition to these formal requests for materials and bibliographies, a number of exchange programs have been established. In any library collection duplicate copies of books and articles are often unavoidable, and these are offered on exchange to other institutions. In addition, publications can sometimes be ordered specifically to provide MUSAT:sra's part of the exchange agreement. This can be particularly helpful in the case of developing country libraries, who often experience difficulties in obtaining some U.S. publications. Exchange agreements have been established with the University of Ibadan, IITA, and the Institute of Agricultural Research at Samaru, among many others.

The faculty were involved principally in program development for the bean/cowpea CRSP. Approximately 40 man days overseas were contributed to development of program and several other days in development of projects related to the CRSP. All requests for assistance were

filled for development programs in which UCR had expertise. Many projects were considered from CID and some proposal writing was done by UCR faculty in these projects. At present no UCR faculty are serving in projects undertaken by CID. Some CID projects are under consideration by UCR and cooperation on other projects has taken place. Two CID projects were not funded in which UCR had a commitment. For itemization of requests received in the Information Center and those fulfilled by faculty see Appendix III-A and B at end of report.

#### B. Specific Information

The University of California, Riverside has over the years attracted a large number of foreign students because of its program in agricultural science and programs in liberal arts and the sciences. There are 140 foreign graduate students at UCR, counting all foreign countries. Developing country students in the Departments of Botany & Plant Sciences and Soil and Environmental Sciences are as follows:

#### GRADUATE STUDENTS FROM DEVELOPING COUNTRIES

<u>COUNTRY</u>	<u>Botany &amp; Plant Sciences</u>	<u>Soil &amp; Environmental Sciences</u>
Brazil	3	2
Chile	1	
Republic of China	1	
Egypt		2
India	1	

Cont'd.

<u>COUNTRY</u>	<u>Botany &amp; Plant Sciences</u>	<u>Soil &amp; Environmental Sciences</u>
Iran	5	
Iraq	1	1
Korea	1	
Libya		1
Malawi	1	
Mexico	2	1
Morocco	1	
Nigeria		1
Pakistan		2
Sudan	12	4
Taiwan	1	
Tanzania	—	1
<b>Totals</b>	<b>30</b>	<b>15</b>

These students, along with the entire graduate student body, are invited to attend the seminars and lectures sponsored by the Project. The entire group often benefits greatly from the questions and discussion offered by graduate students from the developing countries at the Project seminars, and the free exchange of ideas and experiences offers education in its best and truest sense.

### C. Linkages

Important elements in establishment and maintenance of linkages, both international and domestic, are personal visits and travel by

program staff. Travel during the last year was limited to project and development objectives. These are briefly summarized as follows:

1. Dakar, Senegal. Discussion and planning with ISRA, IITA, Cornell University and Boyce Thompson Institute for Plant Research concerning cooperative project proposal on cowpea improvement.

2. East African Countries; Kenya, Tanzania, Malawi, Botswana, Zaire, and in West Africa Nigeria as part of Bean/cowpea-CRSP. (See Appendix V Bean/Cowpea-CRSP Report).

Two types of linkages were developed during the life of the grant.

1) Information Center linkages and 2) other program linkages covering the remaining MUSAT:era activities. See Appendix IV for partial summation of linkages.

#### D. Utilization of Institutional Response Capacities on Solution of Developing Country Problems

MUSAT:era worked towards solutions of two major problems in the Sahel and other semi-arid tropical regions. The first of these problems is the need for information for development. This need is felt in the developed nations focusing attention on international development and in the developing countries. Many of the activities of the Information Center have been directed toward the solution of this problem beyond its primary goal of supporting MUSAT:era research.

Although MUSAT:era can serve a limited clientele in the semi-arid tropics with information related to the program, its effectiveness in document delivery is limited by lack of funds and a concentrated program

for the region. The formation of CIDNET as a functioning unit could greatly enhance the MUSAT:era document delivery program while broadening the information base.

MUSAT:era has devoted a considerable time in promoting CIDNET and at present the bibliographic index data base for each of the five universities comprising CIDNET is on a computer printout system (TRIM) and is completely searchable. A proposal for delivery of documents was made to AID in 1976 by MUSAT:era, but not all CIDNET member universities had their data bases complete and operative. Since this problem has now been solved a proposal for a document delivery system for the developing countries was submitted to AID in February 1979. No action has been taken on this proposal. A one year interim proposal was submitted to AID in October 1979 for operational funds to convert to a CIDNET Center. This proposal is expected to be funded.

The second major problem MUSAT:era has worked on concerns research projects and technical training that can be used to increase food production in these regions. The areas covered by present research include soil-water crop relationships, farming systems and management of soil, water and crop production. The research in Upper Volta is designed to provide basic information for planning and developing farming system approaches, and to provide information on erosion and run-off. The simulation modeling project initiated in Senegal is designed to test data available at CNRA Bamboey. The results of these studies can be applied to large areas in the Sahel as well as other semi-arid tropic areas, thus broadening the significance of this research and its influence on crop production.

Because these research projects were conducted within the Sahel region they can be continued by researchers within the region if desired, data is applicable with little adaptation, and projects can be continued with cooperative assistance from Project faculty members at UCR.

One of the major problems in the drier areas of the Sahel (300-500mm rainfall) concerns management of soils and the available water to provide consistent and stable crop production. A very large part of the population lives in the drier regions, and little progress has been made in assisting the farmers in maintaining stability in crop production. MUSAT:era, IITA and representatives of Senegal as major cooperators met in June 1977 and developed a draft proposal applicable to the drier regions. This would be a beginning to assist the farmers in developing a stable production system through research and application. No action was taken by AID on this proposal even though ISRA had requested assistance. The Title XII, Bean/ Cowpea CRSP was being considered and this may have delayed action on the proposal.

A very small proposal for conducting research on cowpeas in Senegal by A. E. Hall will probably be funded by the Bean/Cowpea-CRSP if this program is funded. However, the expertise gained by the UCR faculty under the 211(d) grant in cowpea production and in various areas related to production is only being partially utilized.

## VII. INVOLVEMENT OF MINORITY PERSONNEL AND WOMEN

All positions of employment in the Project are recruited through regular University procedures, following UCR's guidelines for Affirmative Action and Equal Employment Opportunity.

Because of the nature of the Project, and the geographic area of concern, MUSAT:era has always been active in involving minorities in its activities. Efforts have been particularly strong in effecting liaison with the Black Studies Department so as to create an employment pool of minority applications for student and general assistance positions as they open.

During the reporting year Project staff personnel has included the following:

Project Office Staff	1 woman
Information Center Staff	2 women
Students/General Assistants	2 women, one of whom is of Mexican-American extraction
Research Assistants	8 men, one of whom is Black

## VIII. OTHER

In a project of this nature there is always a rather large University contribution in program space, and in faculty and staff time, that is involved in cooperative activities such as planning, evaluating, and directing program activities. UCR has been particularly helpful to the grant

program by providing space at the beginning of the program to house the Information Center, and office space for the Program Director, Librarian and secretary. Excellent cooperation has been extended by all units connected with the Project, but in particular by the UCR Library staff. It is not the intention to delineate complete University support, but rather to point out the significance of this aspect in the 211(d) Project. Some estimate of faculty and staff time may be made using the Objective/Output method as a basis. Time involved by the UCR Accounting Office is not included.

Man Hours

<b>1. Objective/Output No. 1: Central Information Center</b>	
a. Information Resources Team - Composed of five UCR staff and four faculty - 10 meetings and individual consultation	250
b. Executive Committee	30
c. Soil and Environmental Sciences Dept. office services (budget, etc.)	40
<b>2. Objective/Output No. 2: Network of Worldwide Linkages</b>	
a. Part of the Information Resources Team activity	50
b. Executive Committee	30
c. Soil and Environmental Sciences Dept. office services (budget, etc.)	40
<b>3. Objective/Output No. 3: Improved Research Capability and Increased Knowledge Base</b>	
a. Research Team (consisting of four faculty) - Meetings, graduate student committee, individual attention to graduate students by six faculty	2,000
b. Executive Committee	30

	<u>Man Hours</u>
c. Soil and Environmental Sciences Dept. office services (budget, etc.)	40
4. Objective/Output No. 4: Increased Advisory Capacity	
a. Educational Training and Advisory Team - Consisting of three members - Two meetings and individual consultation	20
5. Objective/Output No. 5: Educational Capabilities in Dryland Moisture Conservation and Utilization	
a. Curriculum Development Team - Consists of five members - Two meetings, travel to other universities, consultation, teaching	20
b. Executive Committee	20
c. Soil and Environmental Sciences Dept. office services (budget, etc.)	40
	<hr/>
TOTAL MAN HOURS	<u>2,690</u>

DEPARTMENT OF INFORMATION SERVICES BY GEOGRAPHIC LOCATION:  
 ORGANIZATION AND NUMBER

UNITED STATES		AFRICA		INTERNATIONAL	
ALB	24 (11)	ALGERIA	6 (1)	ARGENTINA	( 0)
ALB/STONEY	12 (24)	BURKINA	3	AUSTRALIA	12 ( 8)
DC SYSTEM	24 ( 8)	BURUNDI	3	BRAZIL	3 ( 1)
DCS	24 (17)	BURUNDI	2	CANADA	15 ( 4)
DELA	6 ( 3)	CENTRAL AFR. REP	2	CHINA	2 ( 4)
DELTA	17 ( 4)	CHAD	2 ( 2)	CHINA	( 3)
DELTA	17 ( 4)	EGYPT	12 (10)	CHINA	( 3)
CALIFORNIA	61 (16)	ETHIOPIA	4 ( 3)	COSTA RICA	1
CONGRASS	14	GAMBIA	1	COLO	( 3)
DIST. OF COLUMBIA	18 (16)	Ghana	14 ( 3)	ENGLAND	18 ( 6)
FLORIDA	1	GUINEA	3	FRANCE	16 ( 3)
GEORGIA	1	IVORY COAST	7	GERMANY	5 ( 4)
HAWAII	2	KENYA	12 ( 3)	GUATEMALA	3 ( 4)
ILLINOIS	3	LESOTHO	5 ( 3)	HAWAII	2
ILLINOIS	9 ( 3)	LIBERIA	6	INDIA	14 ( 3)
INDIANA	10 ( 4)	MALI	12 ( 4)	IRAN	9
IOWA	1	MALIBYANIA	7 ( 3)	IRAN	2 ( 3)
KANSAS	1 ( 3)	MEXICO	3 ( 3)	ISRAEL	( 6)
KENTLAND	6	NIGER	10 ( 4)	ITALY (Rome)	12 ( 4)
MASSACHUSETTS	4	NIGERIA	14 ( 3)	JERUSALEM	3
MEICWICAN	11 ( 6)	SIERRA LEONE	1	JERUSALEM	6 ( 3)
MISSOURI	4 ( 3)	SENEGAL	19 ( 9)	KYRGYZSTAN	2 ( 3)
MISSOURI	2 ( 3)	SIERRA LEONE	6	KYRGYZSTAN	1
MISSOURI	2	SOUTH AFRICA	4	MONACO	( 1)
NEW MEXICO	1	SWAZI	14 ( 4)	PANAMA	3 ( 4)
NEW YORK	1	TANZANIA	1	PARAGUAY	5 ( 3)
NEW YORK	2 ( 2)	TANZANIA	4 ( 3)	PERU	1 ( 3)
OHIO	4 ( 3)	TOGO	42 ( 3)	PERU	1
OKLAHOMA	2	TUNISIA	4	RUSSIA	( 4)
OKLAHOMA	9 ( 3)	TUNISIA	2	RUSSIA	( 3)
PENNSYLVANIA	1 ( 1)			RUSSIA	3 ( 3)
TEXAS	12 ( 3)			RUSSIA	1 ( 3)
UTAH	10 ( 3)			RUSSIA	1
VERMONT	2			RUSSIA	( 3)
WASHINGTON	2 ( 3)			RUSSIA	12 ( 3)
WISCONSIN	6			RUSSIA	12 ( 3)
				RUSSIA	1
<b>Total</b>	<b>252 (174)</b>	<b>Total</b>	<b>272 (81)</b>	<b>Total</b>	<b>217 (107)</b>
<b>Comp. Total</b>	<b>497</b>	<b>Comp. Total</b>	<b>214</b>	<b>Comp. Total</b>	<b>124</b>
<b>(1977 - 1979)</b>		<b>(1977 - 1979)</b>		<b>(1977 - 1979)</b>	

EXTENSION SERVICES WHICH HAVE BEEN ASSIGNED CATEGORIES

Asia Africa - 1	Economic Development - 11
Agricultural Development Policies - 3 (6)	Egypt - 3
Agricultural Industries - (2)	Energy Resources (solar, wind, etc.) - 12 (6)
Agricultural Systems - 10 (6)	Extension (all aspects) - 13 (5)
Aquaculture - 6	Extension/Training - 3 (7)
Algeria - 2 (1)	Farm Management - 2 (6)
Aridity/Dry Regions - 6 (7)	Fertilization/Fertilizers - 14 (5)
Bahrain - (1)	Field Crops - (4)
Bahama - 3 (2)	Fire - 1
Climatology/Meteorology - 10 (3)	Flodes/Pasture - 3 (2)
Compass - 17 (8)	Food Processing - (2)
Crop Adaptation/Improvement - 13	Forestry - (2)
Crop Production - 31 (10)	Grasses/Grainlands - (2)
Cropping Systems/Rotation - 17 (3)	Groundwater - 6
Crops Under Adverse Conditions - 6	Hatch & Nutrition (1)
Demonstrations - 6 (3)	India - 1
Development Planning - 16	Irrigation (all types) - 30 (13)
Dow - 1	Jajama - 7 (11)
Documentation/Information Systems, Services - 14 (11)	Lakes/Dams - 1
Drugs (all aspects) - 29	Land Reclamation - (1)
Dryland Farming/ Agribusiness - 10 (11)	Legumes - 14
	Livestock - (1)

## APPENDIX II (continued)

Livestock Production - 12 (4)	Plant-Water Relationships - 44 (7)
Mali - 1 (1)	Planting Date - 2
Maps (all types) - 28 (9)	Rainfall - (3)
Marketing - (2)	Range Management - 19 (7)
Mauritania - 4	Reclamation - (4)
Mechanization - 4	Resettlement/Migration - 2
Mesquite ( <u>Prosopis</u> ) - 4	Rice - 3
Millet - 7 (2)	Root Systems - 4
Modelling - 6	Runoff - 4
Moisture Utilisation/ Rainfall - 8	Rural Development - 8
Natural Resources/Environment/ Ecology - 9	Sahel - 18
Nematodes - 2 (1)	Salinity/Leaching - 10 (5)
Niger - 6 (1)	Savannahs/Grasslands - 6
Nigeria - (2)	Seed & Grain Storage - 2
Nitrogen Fixation - 3	Semi-Arid Regions - (6)
Oil Crops - 3	Senegal - 6
Pastoralism - 5(1)	Silt/Flood Control - 4
Pests - (2)	Socioeconomic Development - 15
Pedology - 3	Soil Fertility/Moisture/ Chemistry - 12 (3)
Pest Management - 11 (3)	Soil Management - 56 (17)
Plant Breeding - 2 (2)	Sorghum - 12 (3)
Plant Protection - 5 (1)	Sudan - (2)

**APPENDIX II (continued)****Tanzania - (1)****Technical Assistance - 19****Tillage - 3****Upper Volta - 5****Vegetation - (3)****Village Studies - 7****Water Conservation/  
Harvesting - 20****Water Management/  
Hydrology - 23 (16)****Weed Control - 2****West Africa - 17 (3)****Wheat - 15**

APPENDIX III-A

Requests for Assistance Received during Reporting Period June 30, 1978 to June 30, 1979  
(EXTENSION JUNE 30 - SEPT. 30, 1979)

A. Requests Attended

Description of Request for Assistance	Whom Did You Assist?	Requestor	Who Funded Assistance	Size of Effort		Results of Assistance
				Dollar	Man Days	
Biblio, articles on soil management (Senegal)	Moctar Toure I.S.R.A. Rice Research Station of Djibelor Senegal	Same	Project	1.10	.2	Aided research updated info.
Root anatomy of grasses & esp. <u>Panicum maximum</u> (articles, citations, other researchers in the field)	Dr. D. P. Taylor, ORSTOM Laboratoire de Nematologie Dakar, Senegal	Same	Project	3.05	1.5	Aided research follow up cita- tions as available
Biblio: crops & irrigation	Michael Carr National College of Agricultural Engineering (SILSOE) Bedford, England	Same	Project	1.75	.3	Working on project & article
Info, biblios on: Drainage systems, dryland agriculture/ farming, rainfed conditions	Dr. Antonio G. Santos, Jr. Instituto Univ- ersitario de Evora Evora, Portugal	Same	Project	3.50	2.00	Aided research & background material for teaching purposes
Biblios on cowpeas, food production & processing methods	Patrick Cochran Research & Devel- opment, Loma Linda Foods Co.	Same	Project	1.15	.2	Research for commercial enterprise
Biblios. & updates on cowpeas for teaching references	Doug Havens Agriculture Dept. Loma Linda Univ. Riverside, CA	Same	Project	1.25	.25	Aided instruction & coursework

APPENDIX III-A (Cont'd.)

Requests for Assistance Received during Reporting Period June 30, 1978 to June 30, 1979  
(EXTENSION JUNE 30 - SEPT. 30, 1979)

A. Requests Attended

Description of Request for Assistance	Whom Did You Assist?	Requestor	Who Funded Assistance	Size of Effort		Results of Assistance
				Dollar	Man Days	
Agric. planning info., info. on project computerized data system & services	Hasser E. Al-Saleh, Ministry of Agric. & Water, Riyadh, Saudi Arabia	Same	Project	1.50	. 3	Cooperation & awareness of computer systems design
All available info. on range management & livestock production & all materials related to Niger	Babara Heinzen Niger Range & Livestock Project U.S. Embassy/Miami U.S. State Dept., Washington, D.C.	Same	Barbara Heinzen	No Cost	15.00	Consulted collection at length (from Apr. 3-Apr. 20, 1979). Extensive/comprehensive research & duplication of materials to provide a base of materials for Info. Center of Niger Range & Livestock Project
Biblio. on cassava & info. on geographical distribution of cassava	Bonnie Landa World Life Research Institute Colton, CA	Dr. Bruce W. Halstead	Project	2.25	.5	Aided research & lecture preparation
References on cowpeas in relation to night temperature on yield	Dave Garza UCR Grad student Bot. & Pl. Sci.	Same	Project	2.50	.5	Assisted literature research
Biblio. on cowpeas & info. on plant breeding & temp. effects	Dr. Bruce C. Iarrie & Dr. Don Beech, CSIRO. Div. of Tropical Crops & Pastures Cunningham Lab., Brisbane, Australia	Same	Project	3.20	.5	Provided additional ref's for research projects

APPENDIX III-A (Cont'd.)

Requests for Assistance Received during Reporting Period June 30, 1978 to June 30, 1979  
(EXTENSION JUNE 30 - SEPT. 30, 1979)

A. Requests Attended

Description of Request for Assistance	Whom Did You Assist?	Requestor	Who Funded Assistance	Size of Effort		Results of Assistance
				Dollar	Man Days	
Info. on providing major crop info at small farm level, cowpeas, implements	John A. Mhville, Regional Commissioner, Yusuf H. Nabalang'anya Nat'l Exec. Committee (Members of Parliament of Tanzania)	Same	Project	5.20	1.00	Provided info. to assist in agricultural policy development
Info. on arid & semi-arid crops, publications, articles on same	Dr. A. S. El-Beltagy Faculty of Agric. Ain Shames Univ. Shubra El-Khima, Egypt	Same	Project	6.75	1.5	Provided info. for Egyptian project, "New Crops for Arid & Semi-Arid Zones" sent pub.
Biblio. on sorghum & citations on photo-period	Jim Ferguson UCR Grad Student Pl & Path Dept.	Same	Project	1.05	.3	Aided graduate research
Info. on soil management, esp. aspects of soil crusting (primarily U.S. pub.)	David Giles Hunting Technical Services, Ltd. Hertsford, England	Same	Project	1.30	.3	Aided research & literature search on U.S. materials assisted consultative work
Info. on jojoba, all aspects	Larry Sterling Besperia, CA	Same	Project	.50	.2	Public service & referral to Dr. Yermanos program on jojoba
Biblio: cowpeas, nematodes/nematology, screening for resistance, nematode diseases of tuber crops, esp. yams	Dr. Raphael Odihirin, Visiting Prof., UCR Nematology Dept. (from Nigeria)	Same referred by Dr. Van Gundy, UCR	Project	ongoing assistance (6 mo. project)		Assisted research project & provided background materials for teaching/extension purposes

APPENDIX III-A (Cont'd.)

Requests for Assistance Received during Reporting Period June 30, 1978 to June 30, 1979  
(EXTENSION JUNE 30 - SEPT. 30, 1979)

A. Requests Attended

Description of Request for Assistance	Whom Did You Assist?	Requestor	Who Funded Assistance	Size of Effort Dollar Man Days		Results of Assistance
Materials, publications, info. on Info. Center resources, services and collection	Lanzhou Institute of Desert Research (Academia Sinica) Peking, China	Same, thru Bob Ford	No Cost	---	---	Provided materials & info. sent through scientific exchange program arranged by National Geographic Society with Institute
Visitation with UCR faculty in Soil Sci., Botany & Pl. Sci. & U.S. Salinity Lab. research programs dealing with food production	Dr. Ahmed Bakr, Faculty of Agriculture, Cairo Univ.	Nat. Acad. of Sci. Natl. Research Council (Wash, D.C.)	Project	3.00	1.00	Developed ties with research programs in Egypt Exchange ties for materials. Aided teaching effectiveness
To establish cooperation with univ's. & org's, info. on research programs, info. on arid lands agric. info. on developing self-sufficient desert communities	Adli Bishey, Dir., Desert Development Demonstration & Training American Univ. Cairo, Egypt	Same	Project	3.25	.4	Develop cooperation for project, provide awareness of campus expertise, info. on desert develop. applications
Info. on mechanism of drought-induced earliness for cowpeas & other crops. Also flowering date, growing season, cycle length & growth stages for short-cycle crops	David A. Grants, Grad. Student in Bot. & Pl. Sci., UCR	Same	Project	1.75	.5	Support new research design & literature search for graduate study

## APPENDIX III-A (Cont'd.)

Requests for Assistance Received during Reporting Period June 30, 1978 to June 30, 1979  
(EXTENSION JUNE 30 - SEPT. 30, 1979)

## A. Requests Attended

Description of Request for Assistance	Whom Did You Assist?	Requestor	Who Funded Assistance	Size of Effort		Results of Assistance
				Dollar	Man Days	
Info., ref. on practice of ley farming in seasonally-dry and/or tropical climates	Dr. Robert L. McCown, CSIRO Div. of Tropical Crops & Pastures, Davies Lab., Townsville, Australia	Same	Project	5.60	1.5	Extensive search of data base for lists of descriptors for project use
Inf. pkg. on range management & forestry in Kenya	Dr. Hugh Bollinger, Plant Resources Inst., Salt Lake City, Utah	Same, referred by Dr. Henry CIDNET	Project	4.00	1.00	Extensive search of data base for all available references, background country info. for overseas project assignment
Library/documentation development to expand library in international food & agric. problems	Dr. Ervin Smith, Montana State Univ., College of Agric., Bozeman, Montana	Same Referred from CIDNET	Project	1.50	.5	Provided microfiche copy and data base holdings of info. about acquisition system & referrals for lib. development
Info. about data base materials relating to irrigation & drainage	Dr. Aleman, Instituto Investigaciones de Riego y Drenaje (Drainage + Irrigation Research Institute) Ministry of Agriculture of Cuba and Representation of F.A.O. Project	Same	Project	.75	.2	Provided publications & inf. concerning topics & add. info. services aided research

APPENDIX III-A (Cont'd.)

Requests for Assistance Received during Reporting Period June 30, 1978 to June 30, 1979  
(EXTENSION JUNE 30 - SEPT. 30, 1979)

A. Requests Attended

Description of Request for Assistance	Whom Did You Assist?	Requestor	Who Funded Assistance	Size of Effort		Results of Assistance
				Dollar	Man Days	
Biblio. search on livestock & cattle in northern Nigeria-- pastoral sector & ranching	Dr. Michael Watts, Univ. of CA, Berkeley, Dept. of Geo. Berkeley, CA	Same	Project	1.00	.4	Sent ref's to aid project & background materials
Available info. on dryland agric., pub. & description of info. facilities & services	M.S. Khan Rana, Dir., Agric. Training Inst., Rahim Yar Khan, Pakistan	Same	Project	3.20	.3	Cooperation & exchange for developing Institute activities
Materials for documentation center in Upper Volta, research reports of Robert Ford's work in Upper Volta and any inf. relating to soil & Pl. Sci.	Arlan McSwain, Program for Semi-Arid Food Grains Research & Devel. (AID project)	Same, referred by Dr. Paul Christensen, Chief of Party SAFGRAD Upper Volta	Project	12.00	2.00	Assistance to USAID project & related personnel in research & provided materials for Upper Volta Documentation Center
Available agricultural info. relating to Tanzania	Johnson Semoke, Grad. Student, Soil & Env. Sci. Dept., UCR	Same	Project	1.00	.2	Background info. for graduate research project
Inf. on information services & facilities on dryland agriculture research	K. T. Friedrich SONACOS Cooperation Technique Morocco	Same	Project	1.75	.3	Promote cooperation, exchange & assistance for developing country research projects
Info. on information system & services, possible linkages & referral services as well as material exchanges	Rene Mavis TOOL Foundation (Technical Development with Developing Countries) Amsterdam, Netherlands	Same	Project	2.50	.4	Promote & establish info. & materials exchange linkages Helped to expand awareness & referrals

APPENDIX III-A (Cont'd.)

Requests for Assistance Received during Reporting Period June 30, 1978 to June 30, 1979  
(EXTENSION JUNE 30 - SEPT. 30, 1979)

A. Requests Attended

Description of Request for Assistance	Whom Did You Assist?	Requestor	Who Funded Assistance	Size of Effort Dollar Man Days		Results of Assistance
Location of information on soil productivity, annual rainfall & kinds of crops grown in Sudan & Africa	Lil Ferrell Univ. of Missouri - Columbia, Indust. & Tech. Referral Center, Columbia, Missouri	Same, referred by Mich.St. Univ.	Project	5.20	.75	Assistance to locate references & sources of professional expertise
Biblio., ref., suggestion for info. on production & utilization of bean & cowpeas along with current research on these crops	Caroline Boisington Beans/Cowpea Planning Program Mich. St. Univ. Dept. of Crop & Soil Sci., East Lansing, Michigan	Same	Project	8.75	.75	Provided extensive cowpea bibliography for literature search to aid USAID/Title XII Collaborative Research Support Program
Training materials/info. relevant to rural water supply & sanitation systems in developing countries	Anne Simmons National Water Well Association Worthington, Ohio	Same	Project	3.75	.6	Aided "A.I.D. Knowledge Synthesis Project" to provide info. necessary to eliminate health problems & improve living conditions in developing countries. Also provided list of persons working in this field

APPENDIX III-A (Cont'd.)

Requests for Assistance Received during Reporting Period June 30, 1978 to June 30, 1979  
(EXTENSION JUNE 30 - SEPT. 30, 1979)

A. Requests Attended

Description of Request for Assistance	Whom Did You Assist?	Requestor	Who Funded Assistance	Size of Effort Dollar Man Days		Results of Assistance
Info./publications/ annual reports relating to research for irrigated croplands	Dr. Terd Charoenwatana Khon Kaen Univ. Faculty of Agri. Khon Kaen, Thailand	Same referred from article on proj. activities	Project	4.35	.7	Promoted cooperation & awareness for Ford Foundation & IDRC supported cropping systems projects. Aided research for irrigated cropland under rainfed conditions
Research info./pub- lications relating to water management & crop production under rainfed conditions	R. K. Sivanappan Tamil Nadu Agri. Univ. College of Agric. Engineering, Tamil Nadu, India	Same referred from article on proj. activities	Project	3.65	.5	Cooperation & info. support for applied project for crop production
Inf. on soil moisture regimes for dry zones (semi-arid tropics). Also simulation models on soil moisture studies. Request for Annual Report No. 3 ('76-'77)	S. Dimantha, Soil Chemist, Land Use Div. Irrigation Dept., Colombo, Sri Lanka	Same, referred by Dr. J.C. Dijkerman, an Advisor	Project	2.15	.4	Assisted Ph.D. research project in cooperation with Agri. Univ., Wageningen, Netherlands
Inf. about MUSAT & literature relating to irrigation & drainage	Ir. G. Naber, Librarian, International Institute for Land Reclamation & Improvement, Wageningen, Netherlands	Same referred from articles in pub.	Project	1.30	.3	Provided brochures & thesaurus for refer- ence & referral to microfiche data base at Royal Tropical Institute in Wageningen

APPENDIX III-A (Cont'd.)

Requests for Assistance Received during Reporting Period June 30, 1978 to June 30, 1979  
(EXTENSION JUNE 30 - SEPT. 30, 1979)

A. Requests Attended

Description of Request for Assistance	Whom Did You Assist?	Requestor	Who Funded Assistance	Size of Effort		Results of Assistance
				Dollar	Man Days	
Inf. on TRIM computer services & references for desertification, salinity problems & impact of energy on water resources for dryland agriculture	Juliane Heyman Checchi Co. Washington, D.C.	Same (telephone request)	Project	3.80	.65	Research references for a 2 yr. project (a previous requestor)
References for irrigated farming, feed crops, r/cs, millet, sorghum, poultry, farm management & soil data for Mali	Madou Diakite c/o M. K. International, Boise, Idaho	Same (telephone request)	Project	6.20	.80	References & bibliographies relating to graduate student research on Mali. Assist foreign student exchange program
Biblio., references on intercropping, cropping systems, crop pests & crop water requirements. Also copies of articles selected from previously sent references.	Thomas LeSuer c/o Peace Corps Lesotho, Maberu, Lesotho	Same	Project	6.35	1.2	Assisted special research project & establishment of a resource library (previous requestor)
Inf. on computerized data base, copies of symposium papers on mixed farming, dryland farming practices, soil erosion & traditional agricultural marketing.	Dr. Pans Konandreas International Livestock Centre for Africa (ILCA) Addis Ababa, Ethiopia	Same	Project	7.25	1.4	Provided materials & information for Kenya Country Program

APPENDIX III-A (Cont'd.)

Requests for Assistance Received during Reporting Period June 30, 1978 to June 30, 1979  
(EXTENSION JUNE 30 - SEPT. 30, 1979)

A. Requests Attended

Description of Request for Assistance	Whom Did You Assist?	Requestor	Who Funded Assistance	Size of Effort		Results of Assistance
				Dollar	Man Days	
References for dryland farming in Middle East & North Africa, especially Algeria & Israel	Ms. A. E. L. Maki, Kefar Shmaryahu, Israel	Same	Project	4.15	.7	Aided research project
Info./references on soil management, soil moisture, hay, fodder crops, forage & grain storage in respect to India & sheep farm management	G. C. Goddard, Farm Manager, Raymond Woollien Mills, Ltd., Research & Dev. Div., Maharashtra, India	Same	Project	4.10	.80	Provided research info. to assist production of sufficient fodder to maintain & expand the sheep farm
Publications, everything available, exchange program for info. on sorghum, pearl millet, pigeonpeas, groundnuts, farming systems, village-level studies in agricultural development & agricultural economics in the semi-arid tropics	P. S. Jadhav International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Hyderabad, India	Same	Project	8.35	1.75	Established an active exchange program of info. & publications, promoted communication & cooperation with a world center
Information for research projects on water management under semi-arid conditions & brochures on services	Dr. Luis A. Gurovich, Pontificia Universidad Catolica de Chile, Santiago, Chile	Same	Project	1.20	.2	Assisted research projects being developed in cooperation with the International Atomic Energy Agency

APPENDIX III-A (Cont'd.)

Requests for Assistance Received During Reporting Period June 30, 1978 to June 30, 1979  
(EXPOSURE JUNE 30 - SEPT. 30, 1979)

A. Requests Attended

Description of Request for Assistance	Who Did You Assist?	Requester	Was Funded Assistance	Size of Effort Dollar Non Days	Results of Assistance
Names & addresses of researchers, data, sources & information on quantity & quality of water recharges, irrigation return flow recharge, surface water—ground water quality relationships & techniques to estimate recharge rates	L. G. Wilson, Hydrologist, Univ. of Ariz., College of Earth Sciences, Water Resources Research Center, Tucson, Arizona	Same	Project	5.15 .6	Info. services for research project on recharge to alluvial basins in arid & semi-arid climates in cooperation with U.S. Geological Survey
Computerized data base search on soil-vegetation interactions (effects of vegetation on chemical & physical properties of soils in arid & semi-arid environments. Materials in English, French & Spanish	Sergio L. Rind Universidad de Chile, Servicio de Desarrollo Científico, Asistencia y de Cooperación Internaci., Santiago, Chile	Same, forwarded by Janet Rardin, Overseas Programs/ UCLA	Project	9.50 2.00	Assisted applied research project & established new linkage for exchange of info. & materials
Info. on CIMNET network services & Riverside data base, publications & the International Symposium proceedings	Dr. Fahia M. Muhai, Riyadh Univ., College of Agric., Riyadh, Saudi Arabia	Same, visitor referred by faculty member	Project	1.50 .2	Facilitated cooperation, exchange of ideas, info. & publications

APPENDIX III-A (Cont'd.)

Requests for Assistance Received during Reporting Period June 30, 1978 to June 30, 1979  
(EXTENSION JUNE 30 - SEPT. 30, 1979)

A. Requests Attended

Description of Request for Assistance	Whom Did You Assist?	Requestor	Who Funded Assistance	Size of Effort Dollar Man Days		Results of Assistance
Materials & Proceedings of International Symposium, research contacts in food production & info. on project, campus services	Dr. Abdul Memon Al-Farjani, College of Agric. & Food Sciences, King Fahd Univ. of Petroleum & Minerals, Saudi Arabia	Same, visitor referred by faculty member	Project	1.50	.2	Presented cooperation, new research contacts & an exchange of materials
Selected materials from bibliographic listings on farming systems, livestock & food grain production, animal traction & mechanized farming	Dr. William L. Hall, Chief of Party, ICADAL Project, International Center for Arid & Semi-Arid Land Studies, (ICADAL), Lubbock, Texas	Same referred by COURTESY	Project	14.00	1.5	Assisted country program design, operation & applications. Research materials for individual team member projects
Info. on management of resource documents & computerized systems. Bibliographies on farming systems and land management	Dr. S. S. Meeker, Chief, ICADAL Project, Utah State Univ., Dept. of Agric. & Irrigation Engineering, Logan, Utah	Same	Project	5.00	1.00	Assisted major research project, provided extensive materials on information storage and handling

APPENDIX III-B

Requests for Assistance Received during Reporting Period June 30, 1978 to June 30, 1979  
(EXTENSION JUNE 30 - SEPT. 30, 1979)

A. Requests Not Fulfilled

Description of Request for Assistance	Name/Organization/Location	Requestor	Who Funded Assistance	Size of Effort Dollar Man Days		Why Request Not Fulfilled
<p>Research problem info. on cultivation of edible pea pods, i.e., snowpea and Chinapea varieties. Type and characteristics of soil, fertilizers, expected yields, irrigation, diseases, cost breakdown, marketing</p>	<p>Rocio M. Narban Documentation &amp; Info. Division Central American Research Institute for Industry Guatemala</p>	<p>Same</p>	<p>No cost</p>	<p>—</p>	<p>—</p>	<p>No specific references for fungus diseases of pea-pods or "ascochita". Question referred to appropriate faculty at UCR who supplied info. Center with names/addresses of specialists in the field, who responded to the inquiry.</p>

## APPENDIX IV

U.S. ORGANIZATIONS & UNIVERSITIES (a representative selection)

ACTION Library, M407  
806 Connecticut Ave., N.W.  
Washington, D.C. 20525

(Duplicate exchange listing)

AFRICAN-AMERICAN INSTITUTE  
1201 Connecticut Ave., N.W.  
Washington, D.C. 20036  
(Visitor program)

AFRICAN STUDIES ASSOCIATION  
218 Shiffman Center  
Washington, D.C.  
(National awareness & professional participation)

FORD FOUNDATION  
320 East 43rd St.  
New York, New York 10017  
(Reference support, research inquiries, project documentation)

INTERNATIONAL FOOD POLICY & RESEARCH INSTITUTE (IFPRI)  
1776 Massachusetts Ave., N.W.  
Washington, D.C. 20036  
(Reference service, document loans, research support)

MIDWEST UNIVERSITIES CONSORTIUM FOR INTERNATIONAL ACTIVITIES, INC. (MUCIA)  
Program of Advanced Studies in Institution-Building & Technical Assistance  
Methodology-Indiana University  
1005 East Tenth St.  
Bloomington, Indiana 47401  
(CID referrals, documentation assistance)

NATIONAL ACADEMY OF SCIENCES  
National Research Council  
2101 Constitution Ave.  
Washington, D.C. 20418

OVERSEAS LIAISON COMMITTEE  
American Council on Education  
One Dupont Circle  
Washington, D.C. 20036  
(Visitor program participation)

**PLANT RESOURCES INSTITUTE**  
 360 Wakara Way  
 Salt Lake City, Utah 84108

**ROCKEFELLER FOUNDATION**  
 1133 Ave. of the Americas  
 New York, New York 10036  
 (Project references, research)

**SOCIETY FOR INTERNATIONAL DEVELOPMENT (SID)**  
 1346 Connecticut Ave., N.W.  
 Washington, D.C. 20036  
 (Reference network participation)

**SOUTHEAST CONSORTIUM FOR INTERNATIONAL DEVELOPMENT**  
 Research Triangle Institute  
 Research Triangle Park, N.C. 27709  
 (CID referral)

**TAMS/AGRICULTURAL DEVELOPMENT GROUP**  
 345 Park Avenue  
 New York, New York 10022  
 (Visitors, project documentation support)

**VOLUNTEERS IN TECHNICAL ASSISTANCE, INC. (VITA)**  
 3706 Rhode Island Ave.  
 Mt. Rainier, Maryland 20822  
 (Information services, referral)

**NATIONAL WATER WELL ASSOCIATION**  
 500 West Wilson Bridge Rd.  
 Worthington, Ohio 43085

**CID/CIDNET UNIVERSITIES**

- 1) Colorado State University  
 Fort Collins, Colorado 80523
- 2) New Mexico State University  
 Las Cruces, New Mexico 88003
- 3) Oregon State University  
 Corvallis, Oregon 97331
- 4) Texas Tech University  
 Lubbock, Texas 79409
- 5) University of Arizona  
 Tucson, Arizona 85721
- 6) California State Polytechnic University  
 Pomona, California
- 7) University of California, Riverside  
 Riverside, California 92521
- 8) University of Idaho  
 Moscow, Idaho 83843

- 9) Utah State University  
Logan, Utah 84322
  - 10) Washington State University  
Pullman, Washington 99164
  - 11) Montana State University  
Bozeman, Montana 59717
- (Project support, reference & referral services, information systems and network)

**BOSTON UNIVERSITY**  
African Studies Library  
771 Commonwealth Ave.  
Boston, Massachusetts 02215  
(Duplicate exchange, documents)

**MICHIGAN STATE UNIVERSITY**  
Sahel Documentation Center  
International Studies Library  
East Lansing, Michigan 48824  
(Duplicate exchange list, documentation, reference)

**NORTHWESTERN UNIVERSITY**  
African Studies Program  
Melville J. Herskovits Library  
Evanston, Illinois 60201  
(Duplicate exchange, documents)

**PURDUE UNIVERSITY**  
Department of Agricultural Economics  
West Lafayette, Indiana 47907  
(Duplicate exchange, information services)

**STANFORD UNIVERSITY**  
Food Research Institute  
Stanford, California 94305  
(Duplicate exchange list, reference)

**SYRACUSE UNIVERSITY**  
E.S. Bird Library/Area Studies  
Syracuse, New York 13210

**UNITED STATES DEPT. OF AGRICULTURE**  
Science & Education Administration  
Agricultural Research-Western Region  
Irrigated Agriculture Research &  
Extension Center  
P.O. Box 30  
Prosser, Washington 99350

UNIVERSITY OF CALIFORNIA, BERKELEY  
Library  
Berkeley, California 94720  
(Information services)

UNIVERSITY OF CALIFORNIA, LOS ANGELES  
African Studies Program  
Los Angeles, California 90024

UNIVERSITY OF MISSOURI-COLUMBIA  
Industrial & Technical Referral Center  
1020 Engineering Bldg.  
Columbia, Missouri 65201

AFRICAN ORGANIZATIONS & INDIVIDUALS SERVED (a representative selection)

ASSOCIATION OF FACULTIES OF AGRICULTURE IN AFRICA  
University of Nairobi  
P.O.B. 30197  
Nairobi, Kenya  
(Information services, research)

ASSOCIATION OF AFRICAN UNIVERSITIES  
P.O.B. 5744  
Accra-North, Ghana  
(Information services)

BUREAU INTERAFRICAIN DES SOLS (BIS)  
B.P. 1352  
Bangui, Central African Republic  
(Documents exchange)

UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA (UNECA)  
P.O.B. 3001  
Addis Ababa, Ethiopia  
(Information services, project support)

UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP)  
P.O.B. 30552  
Nairobi, Kenya  
(Information services, reference)

CAMEROON

PANAFRICAN INSTITUTE FOR DEVELOPMENT (PAID)  
B.P. 4078  
Douala, Cameroon  
(Information services, reference)

**CENTRE D'INFORMATION, DE DOCUMENTATION ET D'ETUDES DU PLAN**  
B.P. 675  
Yaounde, Cameroon  
(Information services)

**CHAD**

**OFFICE DE LA RECHERCHE SCIENTIFIQUE ET TECHNIQUE OUTRE-MER (ORSTOM)**  
B.P. 65  
Fort Lamy, Chad  
(Reference services)

**SERVICE METEOROLOGIQUE DE LA REPUBLIQUE DU TCHAD**  
B.P. 429  
Fort Lamy, Chad  
(Reference services)

**ETHIOPIA**

**INSTITUTE OF AGRICULTURAL RESEARCH (IAR)**  
P.O.B. 2003  
Addis Ababa, Ethiopia  
(Duplicate exchange list, research services)

**INSTITUTE OF DEVELOPMENT RESEARCH**  
Documentation Centre  
Addis Ababa University  
P.O. Box 1176  
Addis Ababa, Ethiopia

**INTERNATIONAL LIVESTOCK CENTER FOR AFRICA (ILCA)**  
P.O.B. 5689  
Addis Ababa, Ethiopia  
(Duplicate exchange list, information services)

**GHANA**

**ANIMAL RESEARCH INSTITUTE**  
P.O.B. 20  
Achimota-Accra, Ghana  
(Research services)

**COUNCIL FOR SCIENTIFIC & INDUSTRIAL RESEARCH**  
P.O.B. M.32  
Accra, Ghana  
(Duplicate exchange list, information services)

UNIVERSITY OF GHANA  
The Balme Library  
Legon, Accra, Ghana

UNIVERSITY OF SCIENCE & TECHNOLOGY (UST)  
University P.O.  
Kumasi, Ghana

GUINEA

K.K. Kourouma, Dir.  
DIVISION DES SCIENCES EXACTES ET NATURELLES  
INSTITUT NATIONAL DE RECHERCHE ET DE DOCUMENTATION DE GUINEE  
B.P. 561  
Conakry, Guinea  
(Duplicate exchange list, information services)

KENYA

EAST AFRICAN AGRICULTURE & FORESTRY RESEARCH ORGANIZATION (EAAFRRO)  
P.O.B. 30148  
Nairobi, Kenya  
(Research services, documentation)

INSTITUTE FOR DEVELOPMENT STUDIES  
University of Nairobi  
P.O.B. 30197  
Nairobi, Kenya  
(Duplicate exchange list)

INTERNATIONAL COUNCIL FOR RESEARCH IN AGROFORESTRY  
c/o IDRC  
P.O. Box 30677  
Nairobi, Kenya

KENYA COUNTRY PROGRAMME  
International House  
P.O. Box 46847  
Nairobi, Kenya

LESOTHO

NATIONAL UNIVERSITY OF LESOTHO  
P.O. Roma  
Lesotho, Africa

LIBERIA

WEST AFRICA RICE DEVELOPMENT ASSOCIATION (WARDA)  
 Documentation Division  
 E.J. Roye Memorial Bldg.  
 P.O.B. 1019  
 Monrovia, Liberia  
 (Duplicate exchange list, information services)

MALI

S. Sissoko, Dir. Gen.  
 INSTITUT D'ECONOMIE  
 Rurale Rue Mohamed V  
 P.B. 1098  
 Bamako, Mali  
 (Duplicate exchange list)

Dr. L. Stroosnijder  
 PRODUCTION PRIMAIR AU SAHEL (PPS)  
 B.P. 1704  
 Bamako, Mali  
 (Documentation, information services, references)

P. Poulain  
 IRAT/MALI  
 B.P. 438  
 Bamako-Sotuba, Mali  
 (Research services, publications)

J. Sissako  
 SERVICE METEOROLOGIQUE DU MALI  
 B.P. 237  
 Bamako, Mali  
 (Information services)

MAURITANIA

DIRECTEUR GENERAL DE L'AGRICULTURE  
 Chiekh Bensani Yoube  
 Nouakchott, Mauritania  
 (Information services)

USAID/RAMS  
 Nouakchott, Mauritania, I.D.  
 Department of State  
 Washington, D.C. 20520

**NIGER****AGRYMET CENTER (CILSS/WHO Sahel)**

B.P. 328

Niamey, Niger

(Duplicate exchange list, research &amp; reference services)

**CENTRE DE FORMATION ET D'AGROMETEOROLOGIE ET HYDROMETEOROLOGIE**

APPLIQUE DANS LE SAHEL

B.P. 256

Niamey, Niger

(Information services)

**NIGER INSTITUTE FOR AGRONOMY RESEARCH**

B.P. 429

Niamey, Niger

(Research services)

**NIGER RANGE & LIVESTOCK PROJECT**

U.S. Embassy/Niamey

U.S. Dept. of State

Washington, D.C. 20520

I. Insa, Dir.

**DOCUMENTATION CENTER OF THE RIVER NIGER COMMISSION**

B.P. 933

Niamey, Niger

(Duplicate exchange list, publications)

**NIGERIA****AID/USDA**

Major Cereals Research Project Team

Zamuru, Zaria, Nigeria

(Project research services)

**AHMADU BELLO UNIVERSITY**

Kashim Ibrahim Library

Zaria, Nigeria

(Duplicate exchange list)

**INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE (IITA)**

Library &amp; Documentation Services

Oyo Road

P.M.B. 5320 Ibadan, Nigeria

(Duplicate exchange list, information services)

**INSTITUTE FOR AGRICULTURAL RESEARCH (Samaru)**  
P.M.B. 1044  
Zaria, Nigeria  
(Duplicate exchange list, research services)

**NATIONAL CEREALS RESEARCH INSTITUTE**  
Moor Plantation  
P.M.B. 5042  
Ibadan, Nigeria  
(Duplicate exchange list)

**B. R. Taylor**  
Joint Project 26  
P.O.B. 1062  
**KANO AGRICULTURAL STATION**  
Kano, Nigeria

**UNIVERSITY OF PORT HARCOURT**  
School of Biological Sciences  
Nigeria

#### SENEGAL

**CENTRE NATIONAL DE DOCUMENTATION SCIENTIFIQUE ET TECHNIQUE (CNDST)**  
B.P. 3218  
Dakar, Senegal  
(Information services)

**G. Baye**  
**CENTRE NATIONAL DE RECHERCHES AGRONOMIQUES (CNRA)**  
B.P. 51  
Bambey, Senegal  
(Duplicate exchange, research projects, information services)

**G.V.V. Rao**  
**CASAMANCE PROJECT**  
Dakar-ID  
Department of State  
Washington, D.C. 20520  
(Duplicate exchange list, publications, research services)

**INSTITUT FONDAMENTAL D'AFRIQUE NOIRE (IFAN)**  
B.P. 3120  
Dakar, Senegal  
(Information services)

**CENTRE DE DOCUMENTATION POUR LE PROGRAMME DE DEVELOPPEMENT DU BASSIN  
DU FLEUVE SENEGAL**  
B.P. 383  
Saint-Louis, Senegal  
(Duplicate exchange list, information services)

M. Toure  
 ISRA-Rice Research Station of Djibelor  
 B.P. 34  
 Ziguinchor, Senegal  
 (Duplicate exchange list, research services)

COUNCIL FOR THE DEVELOPMENT OF ECONOMIC & SOCIAL RESEARCH IN AFRICA (CODESRIA)  
 B.P. 3180  
 Dakar, Senegal  
 (information services)

ORSTOM Centre ORSTOM de Dakar Laboratoire de Nematologie  
 B.P. 1386  
 Dakar, Senegal  
 (Research services, contacts)

### TANZANIA

Faculty of Agriculture, Forestry & Veterinary Sciences  
 P.O. Box 643  
 Morogoro, Tanzania

UNIVERSITY OF DAR ES SALAAM  
 P.O. Box 35063  
 Dar es Salaam, Tanzania

### UPPER VOLTA

AUTORITE POUR LE DEVELOPPEMENT DU LIPTAKO - GOURMA  
 CENTRE DE DOCUMENTATION  
 B.P. 619  
 Ouagadougou, Upper Volta

COMITE INTERAFRICAIN D'ETUDES HYDRAULIQUES (CIEH)  
 Centre de Documentation  
 B.P. 868,  
 Ouagadougou, Upper Volta  
 (Duplicate exchange, publications, reference services)

COMITE PERMANENT INTERETATS DE LUTTE CONTRE LA SECHERESSE DANS LE SAHEL (CILSS)  
 B.P. 7049  
 Ouagadougou, Upper Volta  
 (Information services, reference services)

K. Konate, Dir.  
 SOCIETE AFRICAINE D'ETUDES ET DE DEVELOPPEMENT (SARD)  
 Documentation Center  
 B.P. 593,  
 Ouagadougou, Upper Volta  
 (Duplicate exchange list, publications)

INTERNATIONAL ORGANIZATIONS & INDIVIDUALS SERVED (a representative selection)

AUSTRALIA

ARID ZONE RESEARCH INSTITUTE  
 P.O.B. 291  
 Alice Springs, N.T. 5750, Australia  
 (research services)

COMMONWEALTH SCIENTIFIC & INDUSTRIAL RESEARCH ORGANIZATION (CSIRO)  
 Soils Division  
 P.M.B. 1, Glen Osmond  
 Adelaide, South Australia  
 (research, reference services)

COMMONWEALTH SCIENTIFIC & INDUSTRIAL RESEARCH ORGANIZATION (CSIRO)  
 Division of Tropical Crops and Pastures  
 Davies Laboratory  
 University Road  
 P.M.B. M50 Townsville, QLD. 4810  
 Australia

NEW SOUTH WALES SOIL CONSERVATION SERVICE  
 Box 4293  
 GPO Sydney  
 New South Wales, Australia  
 (information services)

ROSEWORTHY AGRICULTURAL COLLEGE  
 Roseworthy, S.A. 5371

WATER RESEARCH FOUNDATION OF AUSTRALIA  
 P.O. Box 1  
 Kensington, N.S.W. 2033, Australia

CANADA

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE (IDRC)  
 P.O.B. 8500  
 Ottawa, Canada K1G 3H3  
 (Information services)

INSTITUTE FOR INTERNATIONAL DEVELOPMENT  
 University of Ottawa  
 Ottawa, Ontario K1N 6N5 Canada

MCGILL UNIVERSITY  
 Centre for Developing Area Studies  
 3437 Peel Street  
 Montreal 112, Quebec, Canada  
 (Research, reference services)

CHILE

PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE  
 P.O. Box 114-D  
 Santiago, Chile

CHINA

LANZHOU INSTITUTE OF DESERT RESEARCH - ACADEMIA SINICA  
 Peking, China

COLOMBIA

A. de Tovar  
 Centro Internacional de Agricultura Tropical (CIAT)  
 Apartado Aereo 67-13  
 Cali, Colombia  
 (Duplicate exchange list, information services)

COSTA RICA

INSTITUTO INTERAMERICANO DE CIENCIAS AGRICOLAS  
 Andean Zone  
 Apartado 4359  
 San Jose, Costa Rica  
 (Duplicate exchange list)

**CENTRO AGRONOMICO TROPICAL DE INVESTIGACION Y ENSENAZA (CATIE)**  
 Tropical Crops & Soils Department  
 Turrialba, Costa Rica  
 (Information services)

**CUBA**

**INSTITUTO INVESTIGACIONES DE RIEGO Y DRENAJE**  
 (Drainage & Irrigation Research Institute)  
 Apartado 6090  
 Habana, Cuba

**DENMARK**

**INTERNATIONAL WORKING GROUP FOR INDIGENOUS AFFAIRS**  
 Frederiksholms Kanal 4A  
 BK 1220 Copenhagen K, Denmark  
 (Information services)

**EGYPT**

**AIN SHAMES UNIVERSITY**  
 Faculty of Agriculture  
 Shubra El-Khima, Egypt

**A. S. Gonas, Dir.**  
**FIELD CROPS RESEARCH INSTITUTE**  
**AGRICULTURE RESEARCH CENTRE. WHEAT RESEARCH SECTION**  
 Giza, Cairo, Egypt  
 (Duplicate exchange list, research services, information services)

**Adli Bishay, Dir.**  
**AMERICAN UNIVERSITY IN CAIRO**  
**DESERT DEMONSTRATION DEVELOPMENT & TRAINING**

**SOILS & WATER RESEARCH INSTITUTE**  
 Agricultural Research Centre  
 Cairo University Street  
 Giza, Egypt  
 (Duplicate exchange list, research services)

**ENGLAND**

**INTERNATIONAL AFRICAN INSTITUTE**  
 210 High Holborn  
 London WC1V 7BW  
 (Documentation, Information services)

**CENTRE OF WEST AFRICAN STUDIES**  
 University of Birmingham  
 P.O.B. 363  
 Birmingham B15 2TT, England  
 (Duplicate exchange list)

**INSTITUTE OF BRITISH GEOGRAPHERS**  
**DEVELOPING AREAS STUDY GROUP**  
 University College London  
 Gower Street  
 London WC1N 6BT, England  
 (Information services)

**MINISTRY OF OVERSEAS DEVELOPMENT**  
 Land Resources Division  
 Tolworth Tower  
 Surbiton, Surrey KT6 7DY, England  
 (Duplicate exchange list)

**COMMONWEALTH AGRICULTURAL BUREAUX (CAB)**  
 Farnham House, Farnham Royal  
 Slough Bucks, SL2 3BN, England  
 (Publications, information services)

**TECHNICAL COMMISSION FOR COOPERATION IN AFRICA SOUTH OF THE SAHARA**  
 Joint Secretariat  
 Watergate House, York Buildings  
 London WC2, England  
 (Information services)

**FRANCE**

**INSTITUT DE RECHERCHES AGRONOMIQUES TROPICALES ET DES CULTURES VIVRIERES**  
 (IRAT)  
 110, rue de l'Université  
 75340 Paris, France  
 (Reference services, publications)

**GROUPEMENT D'ETUDES ET DE RECHERCHES POUR LE DEVELOPPEMENT DE L'AGRONOMIE  
TROPICALE (GERDAT)**

42 rue Scheffer  
75016 Paris, France  
(Information services, publications)

**OFFICE DE LA RECHERCHE SCIENTIFIQUE ET TECHNIQUE OUTRE-MER (ORSTOM)**

24 rue Bayard  
75008 Paris, France  
(Publications, information services, research services)

**SERVICE DE REFERENCES-DEVELOPPEMENT/DEVELOPMENT REFERENCE SERVICE (SID/DRS)**

49 rue de la Glaciere  
75013 Paris, France  
(International reference service participation, referrals)

**ORSTOM - Service Central de Documentation**

70-74 Route d'Aulnay  
93410 Bondy, France  
(Documentation, publications)

**ORSTOM - Direction Generale**

24, rue Bayard-75008 Paris  
(Research services)

**ORSTOM - Office de Recherches**

B.P. 5035  
34032 Montpellier, France  
(Research contacts, services)

**GERMANY**

**INSTITUT FUR PFLANZENKRANKHEITEN (Plant Diseases)**

Universität Bonn  
Nussallee 9  
D5300 Bonn, West Germany

**GUATEMALA**

**INSTITUTO CENTROAMERICANO DE INVESTIGACION Y TECNOLOGIA INDUSTRIAL (ICAITI)**

(Central American Research Institute for Industry)  
Avenida La Reforma 4-47, Zona 10  
Guatemala

**INDIA**

ALL INDIA COORDINATED RESEARCH PROJECT FOR DRYLAND AGRICULTURE (ICAR)  
2-2-58 Amberpet  
Hyderabad-500013, India  
(Research services, information services)

TAMIL NADU AGRICULTURAL UNIVERSITY  
College of Agricultural Engineering  
Coimbatore - 641003  
Tamil Nadu, India

R. P. Singh  
CENTRAL ARID ZONE RESEARCH INSTITUTE  
Jodhpur-342003, India  
(Duplicate exchange list)

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS (ICRISAT)  
1-11-256 Begumpet  
Hyderabad-500016, A.P. India  
(Research services, information services, publications)

**IRAN**

WHEAT & BARLEY RESEARCH PROJECT  
Seed & Plant Improvement Institute  
Karaj, Iran  
(Research services)

**ISRAEL**

INTERNATIONAL IRRIGATION INFORMATION CENTER (IRRI)  
P.O.B. 49  
Bet Dagan, Israel  
(Information services)

VOLCANI INSTITUTE OF AGRICULTURAL RESEARCH  
P.O.B. 15  
Rehovot, Israel  
(Research and information services)

NEGEV INSTITUTE OF AGRICULTURAL RESEARCH  
P.O.B. 1025  
Beersehaba, Israel  
(Information services)

**ITALY**

**N. R. Carpenter**  
**Agricultural Services Division**  
**FOOD AND AGRICULTURE ORGANIZATION (FAO)**  
**Farm Management Division**  
**Via Della Terme di Caracalla**  
**00100 Rome, Italy**  
**(Research & information services)**

**AGRIS c/o FAO**  
**Via delle Terme di Caracalla**  
**00100 Rome, Italy**  
**(Information services)**

**LEBANON**

**ARID LANDS AGRICULTURAL DEVELOPMENT PROGRAM**  
**P.O.B. 2379**  
**Beirut, Lebanon**  
**(Information & research services)**

**MEXICO**

**Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT)**  
**Londres 40, Apartado Postal 6-641**  
**Mexico 6, D.F. Mexico**  
**(Duplicate exchange list)**

**NETHERLANDS**

**AGRICULTURAL UNIVERSITY**  
**Tillage Laboratory**  
**Diedenweg 20**  
**Wageningen, Netherlands**  
**(Research services)**

**AGRICULTURAL UNIVERSITY**  
**Dept. of Soil Science & Geology**  
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## APPENDIX V

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## SUMMARY

### Research Report

A. E. Hall - Grant Research Leader

This information relates mainly to improved research capabilities and enhanced educational opportunities in dryland farming at UCR.

### INTRODUCTION

During the first year of the project several approaches for improving the response capability of the University of California, Riverside in dryland farming for the semiarid tropics were initiated. It was decided that a broad, field research program that is relevant to the semiarid tropics would enhance response capability in research, education and extension. This was not a trivial task because Riverside is located in a subtropical, winter rainfall, semiarid zone and the area of interest in the Sahel region of West Africa is a tropical, summer rainfall, semiarid zone. In addition, establishment of long-term field research projects was desirable with continuity that was not solely dependent upon the erratic levels of funding that are available for international projects. Consequently, the primary responsibility of the University of California--research and education for California and the United States--had to be taken into consideration. Fortunately, we were able to devise an approach that took advantage of this unique set of circumstances, and has enabled us to substantially enhance our response capabilities in dryland farming for the semiarid tropics.

Our field research program was mainly based upon one crop species because this provided an effective and necessary mechanism for stimulating cooperation between plant scientists, soil scientists, plant pathologists, nematologists, entomologists, etc. Some broadening was achieved by a farming systems project conducted in Upper Volta by a cultural geographer, which will be reported elsewhere, a hydrologic balance study of cropping systems in Senegal, and a comprehensive review of dryland farming which resulted in a book on "Agriculture in Semi-Arid Environments".

We chose cowpea (Vigna unguiculata) for our field research program because it is an important staple food crop of the semiarid tropics, and because this crop has been seriously neglected by research organizations throughout the world. Even the international center responsible for this crop (the International Institute for Tropical Agriculture in Nigeria) has conducted little work on dryland cropping of cowpeas and has only recently established a small research program in the semiarid zone in Upper Volta. In addition, cowpea is well adapted to the summer season at Riverside and is of substantial importance to California agriculture. The Riverside climate offered a unique and important opportunity for investigating dryland cropping of cowpeas. Due to our hot, dry and rain-free summers, we are able to conduct field studies under different controlled levels of water supply (with irrigation). In this way we can simulate different summer rainfall regimes without the serious difficulties that arise in summer rainfall semiarid zones due to highly variable and unpredictable rainfall.

We considered that field research is extremely important for training students and scientists who are to contribute to rural development in the

semiarid tropics. Most universities in the United States do not offer sufficient opportunities for field research that are relevant to agriculture in the semiarid tropics. Field research initiated under this AID 211(d) grant has enabled us to provide these opportunities in field research at the University of California, Riverside. Brief descriptions of research accomplishments, student training and institutional development are presented.

#### AGRONOMIC RESEARCH AND EDUCATION

Agronomic research supervised by Professor A. E. Hall resulted in the training of Dr. K. J. Turk who obtained his Ph.D. in June 1979, and research experience for several other students who were hired as assistants on a temporary basis. This research is reported in the following publications (Turk, Hall and Asbell, 1980, and Turk and Hall 1980a, b, and c).

Management methods have been developed for cowpeas under dryland and intensive cropping systems. Maximum seed yields of 4-1/2 tons/hectare have been obtained under full irrigation, and yields as high as 1 ton/hectare have been obtained with stored soil moisture supplying only 200 mm for crop water use. Some of the management methods, such as the methods used for controlling insects causing flower and pod abscission, may contribute to the development of improved management methods for the semiarid tropics. Insect pests are a major limitation to cowpea production in West Africa.

Drought and high temperature effects on cowpea seed yield were evaluated. These data indicate that for dryland cropping, sowing dates must be chosen that minimize the possibilities of drought at flowering and early pod filling, and of even moderately high day temperatures at flowering. In

contrast, cowpea has tremendous ability to resist drought during vegetative growth and survive drought and high temperatures during all stages of growth. Provisional studies were conducted to determine optimal sowing densities which are being extended at this time.

This phase has resulted in establishment of a long-term research project in cowpea agronomy at the University of California directed by Professor A. E. Hall. This project is involved in the collaborative research support program for cowpeas which is being initiated under Title XII funding at this time. Other projects are present in the University of California on the agronomy of other food crops that are grown in the semiarid and sub-humid tropics such as sorghum, maize and beans.

#### SOIL MICROBIOLOGY RESEARCH AND EDUCATION

Research on nitrogen fixation, supervised by Professor D. D. Focht, has resulted in the training of Dr. R. M. Zablutowicz, who obtained his Ph.D. in December, 1978. These studies are described in the dissertation of R. M. Zablutowicz.

This research focused on the characterization of the ecology and physiology of the rhizobia which nodulate cowpea. Several of the strains of rhizobium which nodulate cowpeas were characterized. Four selected strains were evaluated under field conditions with respect to their ability to nodulate cowpea and fix nitrogen under well-watered conditions and drought. The strains which were used in inoculating seed were recovered from the rhizosphere at the end of the experiments indicating that they had adequate

competitive or survival abilities. Drought substantially reduced nodule mass, nitrogenase activity and nodule efficiency compared with well-watered treatments except for a treatment with one particular strain of rhizobium which was influenced less by drought. The possibilities for selecting strains of rhizobia which maintain adequate nitrogen fixation when subjected to drought were considered.

This phase has resulted in a USDA funded collaborative research project on improving nitrogen fixation of pigeon peas between the University of California, Riverside and the University of Panama which is led by Professor D. D. Focht.

#### SOIL MANAGEMENT RESEARCH AND EDUCATION

Research on cowpea rooting and soil physical conditions was supervised by Professors G. H. Cannell and L. J. Lund, and has resulted in the training of D. Rempel, who obtained an MS degree in December, 1977, and D. L. Gipson, who is completing his graduate studies at this time.

These studies and those of graduate students P. J. Shouse and K. J. Turk demonstrated that in fine sandy loam soils with a high bulk density (1.5 to 1.8 g/cm<sup>3</sup>) the root systems of cowpea develop slowly and are relatively sparse and shallow. Similar soil conditions occur widely in semiarid Africa and limited rooting has important implications for sowing densities, row widths, soil management practices and varietal improvement. We are conducting experiments at this time on optimal sowing densities and row widths in relation to dryland cropping and varietal improvement.

After completing his graduate training, D. Rempel took a job in Upper Volta.

### HYDROLOGIC BALANCE RESEARCH AND EDUCATION

Field studies of the hydrologic balance of cowpeas under varying levels of drought were supervised by Professors W. A. Jury and I. H. Stolzy, and resulted in the training of Dr. P. J. Shouse, who obtained his Ph.D. degree in June, 1979, and research experience for several other students. These studies are reported in the dissertation of P. J. Shouse.

Methods were evaluated by P. J. Shouse for predicting crop water use (transpiration and soil evaporation) of cowpeas under different levels of drought. In addition, the studies of P. J. Shouse and K. J. Turk provided methods for predicting the effects of drought on cowpea yield.

This information has been used to extend the hydrologic budget model developed by Hall and Dancette (1978) and applied to analyze cropping systems in the Sahelian and Sudanian zones of West Africa. Models for predicting water use and yield under drought provide a fundamental basis for guiding field studies for developing improved management methods and varieties for semiarid zones. A hydrologic budget model with the potential for predicting water use and yield under drought has been developed for the International Communications Agency of the U.S. Government by A. E. Hall and K. A. Shackel. However, prior to use in specific regions, this model should be tested and calibrated.

### COWPEA VARIETAL IMPROVEMENT RESEARCH AND EDUCATION

The other projects have provided information concerning the factors limiting cowpea yields in semiarid environments which are being used in

varietal improvement. Professors A. E. Hall and K. W. Foster have directed the varietal improvement project and it has provided training for D. A. Grantz, who obtained his MS degree in June, 1979.

It was hypothesized that reducing the length of the vegetative cycle would improve seed yields under limiting soil water. Single plant selections were made based upon the first appearance of mature pods under well-watered conditions. There is less environmentally induced variability under well-watered conditions, thus greater chance of detecting genotypic differences. Two selections from California Blackeyes have now been yield tested over two years and have substantially improved yields under drought, but similar yield potential to the parents under well-watered conditions. This method could be used for developing varieties for the Sahelian zone of West Africa which have improved drought adaptation and yield stability.

In another project, varieties were selected from materials developed in Senegal and these have been crossed with the best California variety. Selections have been made from 600 relatively pure lines which were developed from these crosses which contain combinations of several desirable characteristics. These lines are useful for breeding programs in California and West Africa, and are being performance tested in two locations in California and through cooperative projects in Senegal and Australia. In addition, germplasm from this project has been supplied to cowpea improvement programs in India and Saudi Arabia. A long term cowpea improvement project for semiarid zones has been established at the University of California, Riverside by Professor A. E. Hall in cooperation with Professor K. W. Foster, who has transferred to the University of California, Davis.

This project is involved in the collaborative research support program for cowpeas which is being initiated under Title XII funding at this time.

#### PEST AND DISEASE MANAGEMENT RESEARCH AND EDUCATION

Prior to this grant, scientists at the University of California, Riverside had developed considerable expertise in the areas of nematology, plant pathology, and entomology that are relevant to cowpea production. Under this grant the Nematology Department, under the leadership of Professor S. Van Gundy, has developed important collaborative projects with nematologists in West Africa. Collaboration has included long-term exchange of senior scientists. Consequently, the scientists in the Nematology Department have substantially enhanced their ability to solve nematological problems in semiarid West Africa and elsewhere. In addition, projects have been conducted in the Pathology Department (funded through other sources) on the root rot disease of cowpea caused by fusarium under the direction of Professor D. Erwin. Considerable expertise is also available at Riverside in the areas of insect, mite and weed control in cowpea cropping systems.

#### CONCLUSIONS

With the assistance of an AID 211(d) grant, the University of California, Riverside has developed an institutional response capability in dryland farming. This capability should be used through cooperative programs in research and education to develop improved cropping systems for the semiarid tropics with special emphasis on cowpeas.

An 18 month study was conducted by Mr. Robert Ford entitled, "Management and Perception of Indigenous Agricultural Systems in a Semi-Arid Region of Northern Upper Volta". An immense amount of data was collected in this study and assimilating it into a final form for publication has been a long, time consuming process. Mr. Ford is in the latter stages of a Ph.D. thesis and hopefully this will be available in the near future. I have read the first 7 chapters and was impressed with the quality of the material. The introduction to this study and the thesis outline are included as a preliminary report rather than a summary of the first 7 chapters.

## PUBLICATIONS - PART OF GRANT OUTPUT

Graduate Student Theses

1. Ford, Robert. Management and Perception of Indigenous Agricultural Systems in a Semi-Arid Region of Northern Upper Volta. In process of completing Ph.D. thesis--estimated date 1980.
2. Grantz, David Arthur. Earliness and Drought Adaptation of Cowpea (Vigna unguiculata (L.) Walp.). M.S. Thesis, August 1979.
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5. Shouse, Peter John. Effect of Water Deficit on the Growth, Yield, and Water Use of a Field-Grown Cowpea Crop. Ph.D. Thesis, June 1979.
6. Stevens, Kirk. Water and Nutrient Relationship of Wheat and Sorghum Irrigated with Power Plant Wastewater. M.S., June 1980.
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8. Zablutowicz, Robert Michael. Characterization, Ecology and Physiology of the Cowpea Rhizobium. Ph.D. Thesis, December 1978.

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1. Cannell, Glen H., Editor. Proceedings of An International Symposium on Rainfed Agriculture in Semi-Arid Regions. University of California, Riverside (UCR). Oregon State University and Consortium for Arid Lands Institute. Published at UCR 1977. (Copies of this publication are still available. Contact Dr. Glen H. Cannell, Soil & Environmental Sciences, UCR, Riverside, CA 92521.
2. Felker, Peter. State of the Art: Acacia albida as a Complimentary Permanent Intercrop with Annual Crops. Published by University of California, 1978.
3. Illes, Doris. Agricultural Research in Semi-Arid Regions--resource directory. G. K. Hall and Co., 1979. Hall, A. E. , Cannell, G. H. and H. W. Lawton, Editors. Agriculture in Semi-Arid Environments, Springer-Verlag, New York, 1979.
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10. Hadas, A. A Simple Laboratory Approach to Test and Estimate Seed Germination Performance under Field Conditions. Agron. J. 69:582-588, 1977.
11. \_\_\_\_\_ Evaluation of Theoretically Predicted Thermal Conductivities of Soils under Field and Laboratory Conditions. Soil Sci. Soc. Am. Proc. 41:460-466, 1977.
12. Hall, A. E. and C. Dancette. Analysis of Fallow-farming Systems in Semi-Arid Africa using a Model to Simulate the Hydrologic Budget. Agron. J. 70:816-823, 1978.
13. Hall, A. E., G. H. Cannell and H. W. Lawton, Editors. Agriculture in Semi-Arid Environments. Springer-Verlag, N.Y., N.Y., 1979.
14. Walsh, Gretchen. Moisture Utilization in Semi-Arid Tropics: Summer Rainfall Agriculture. G. K. Hall and Co., 1977.
15. Zablotowicz, Robert M., Dennis D. Focht and Glen H. Cannell. Modulation and Nitrogen Fixation of Field Grown California Cowpeas as Influenced by Well-Irrigated and Droughted Conditions. Agron. J. Accepted for publication 1980.

## OUTLINE

### Management and Perception of Indigenous Agricultural Systems in a Semi-Arid Region of Northern Upper Volta

#### PREFACE & ACKNOWLEDGEMENTS

#### Section I. INTRODUCTION

##### Chapter 1. The Sahelo-Sudanian Scene

- a) Introduction
- b) Theoretical & Practical Considerations
- c) Choice of Field Study Sites
- d) The Sahel in Relation to the World's Dry-Lands

#### Section II. YATENGA: THE BIOPHYSICAL BASE

##### Chapter 2. Geology, Landforms, and Hydrology

- a) Geology
- b) Landforms
- c) Hydrology

##### Chapter 3. Climate

- a) General Climatic Information
- b) Long-term Climatic Variability
- c) Rainfall Distribution (1977) in Yatenga
- d) Rainfall Intensity and Erosion

##### Chapter 4. Soils

- a) General Overview of Yatengan Soils
- b) The 'Landscape Unit' Classification System
- c) Soil Factors Affecting Agriculture in Yatenga  
(chemical factors, water-holding characteristics,  
runoff and infiltration, erosion)
- d) Soil Capability
- e) Traditional Classification of Soils (1. comp (etc))

##### Chapter 5. Vegetation

- a) Vegetation Domains in Sahelo-Sudanian Upper Volta  
(Broad climatic formations, edaphic vegetation formations)
- b) Relative Proportion of Principal Vegetation Formations in Yatenga
- c) Seasonal Variation in Vegetative Cover
- d) Traditional Utilization and Classification of Vegetation
- e) Introduced Species and Conservation Issues

### **Section III. YATENGA: THE PEOPLE**

#### **Chapter 6. Culture, History, Population, and Settlement**

- a) <sup>it's</sup> Historical Political Backgrounds of Yatenga
- b) Peoples, Languages, and Religions
- c) Population and Settlement Patterns
  - 1) regional patterns
  - 2) village study sites
- d) Social Organization: the Family, Values, etc.

#### **Chapter 7. The Rhythm of Life: Spatial and Temporal Patterns of Living**

- a) Overview of the Annual Cycle of Activities: Farmers vs. Herders
- b) Spatial Patterns of Livelihood: Transhumance and Sedentarization
- c) Interaction Patterns Between Herders and Farmers: Conflict and Cooperation (case studies)

### **Section IV. YATENGA: THE SUBSISTENCE ECONOMY**

#### **Chapter 8. Agricultural Technology and Subsistence Strategy**

- a) Crops and Cropping Systems
- b) Agricultural Technology: Field Crops/Gardening
- c) Environmental and Socio-economic Risks
- d) Adaptation to Risks

#### **Chapter 9. Land and Labor**

- a) Labor Patterns (temporal and spatial variations)
- b) Production (yields), Efficiency and Wastage
- c) Land Use and Land Tenure Patterns
- d) Conflict Resolution in Land Disputes

#### **Chapter 10. Consumption and Distribution**

- a) Diet and Nutrition
- b) Marketing and Exchange
- c) "Money Economy" and "Subsistence": Interaction Patterns and Problems
- d) Interaction of "Non-agricultural" Activities <sup>with</sup> Agriculture

### **Section V. YATENGA: CHANGE AND CONTINUITY**

#### **Chapter 11. The Ecological and Agricultural Predicament**

- a) Famine and Drought: (adaption through time)
- b) Land Degradation and Conservation
- c) Population/Resource Imbalance and Social Change
- d) Modernization and Agricultural Development
- e) Implications of Study for "Cultural Ecological" Theory
- f) Prognosis and Recommendations

### **Section VI. APPENDICES AND BIBLIOGRAPHY**

## CHAPTER I

### THE SAHELO-SUDANJAN SCENE

#### Introduction:

The world concern generated by the recent disastrous droughts and famines in the Sahel has underscored the need for a better understanding of this and other tropical semi-arid regions (Sheets and Morris: 1974; Glantz: 1976; Dalby, Church, and Bezzaz: 1977). Many laymen and even some scientists have a very imprecise picture of both the physical limits and cultural-ecological dynamics of the Sahelian semi-arid environment. This is particularly true in regard to its agricultural systems,<sup>1</sup> and yet agriculture is the main economic pursuit of the people in this region.

Recently an extensive interdisciplinary review of current knowledge on agriculture in the world's tropical semi-arid environments was published under the auspices of MUSAT: era<sup>2</sup> at the University of California, Riverside (Cannell and Hall: 197<sup>9</sup><sub>B</sub>). This study summarized quite adequately what is presently known, at the regional and world-wide scale, about tropical semi-arid agriculture, but it also revealed that still relatively little is known about the "cultural ecology"<sup>3</sup> of subsistence agriculture, particularly at the village and individual peasant level. Stated in another way, we don't yet understand well enough how the obstacles to survival in the Sahel are perceived by the peasant, and what he does to cope with them as an individual or as a collectivity, both under past and under present situations. What resource management strategies and techniques have been developed by peasants to deal with the unpredictable and harsh Sahelian environment? What are the peasant's perceptions and actions, successes and failures, his decision-making and coping behavioral mechanisms for making a living in the Sahel? Seeking the answers to complex questions like these is the substance of "cultural ecology".

Sahelian subsistence economies are highly complex human adaptations to a very risk-prone environment. The "subsistence risks"<sup>4</sup> faced by Sahelian farmers and herders are formidable. From time immemorial they have had to face not only the much publicized "environmental" risks such as drought, animal pests, erosion, and devegetation, but also "socioeconomic" risks such as labor supply fluctuation, accidents or sickness, land tenure disputes, farmer-herder quarrels, inter-ethnic and social class friction. All these risks required that the peasant pastoralist or farmer make careful "resource management" decisions that could directly affect his family's chances for survival. Furthermore, it should be stressed that to the peasant, his decisions and actions were always seen as "rational", irrespective of their apparent "irrationalness" to outsiders. Much therefore can be learned about "coping" with the Sahelian environment by studying "the adaptive mechanisms" (habitual patterns of decision-making) developed by peasant farmers and herders over the centuries.

It is probably safe to say that many of the peasant's traditional approaches to managing environmental risks were relatively successful under past situations (taking into consideration past levels of technology and social organization). Even at present many of the traditional practices make sense and should be encouraged. Unfortunately, since the early 1900's radically new and changing political, economic, and demographic forces have impinged on these basically subsistence economies, often at such a rapid pace that many peasants have not been able to adjust quickly enough their resource management strategies to cope with the new circumstances. Consequently the continued economic viability and ecological stability of many Sahelian societies is in jeopardy.

"New" socioeconomic risks such as commodity price fluctuations, taxation, governmental development policies, rising demand for manufactured goods, and high population growth rates have upset the delicate subsistence systems which

in the past guaranteed the long-term survival of the group without permanent destruction of the environmental resource base. Some agricultural practices which may have been rational and ecologically stable under the low population conditions of pre-colonial times today have too often led to rapid environmental degradation and social disorganization.

The peasant has been generally baffled by the "new" risks he faces and his individual and collective response has not always seemed "rational" to those outside his little world (and on balance it should be stated that societies, like people, do not always make the best decisions possible). Yet, the pragmatic and resourceful nature of the peasant should not be discounted, even under contemporary conditions. It seems only right, therefore, that if new and hopefully adaptive resource management strategies are to be developed and adopted, they will be outgrowths of what the peasant already knows and has proved could work in the past.

It is with these thoughts in mind that this "cultural ecological" case study of life in the Sahel was written. Hopefully the general reader will gain a better appreciation for the cultural and environmental forces that the Sahelian farmer encounters in his every-day struggle to make a living. In a more practical vein it is hoped that data and recommendations presented here will aid development planners and agricultural specialists in their difficult job of establishing sound policies and programs for the eventual containment of the presently out-of-control forces bringing hunger, disease, and poverty to the Sahelian societies.

#### THEORETICAL AND PRACTICAL CONSIDERATIONS

##### Methodological "Borrowing":

Anyone who has done a cultural ecological study will attest to the fact that there is nothing like encountering culture under field conditions to

sharpen one's theoretical and methodological perspectives. This is as it should be, for theory building should be a means of explaining and understanding real life, and not just an abstract exercise. In grappling with the task of explaining how a cultural system has adapted to its environment, it becomes very clear that all aspects of culture are relevant objects of study, and that in reality one can't really separate any part from the whole, be it religion, ecology, history, social structure, or economic patterns. An outgrowth of this realization, is that many geographers who do cultural ecology find it necessary to "borrow" their research methodologies from widely disparate disciplines i.e. economics, anthropology, demography, ecology, in order to adequately explain and understand the multi-faceted nature of the cultural systems they have chosen for field analysis.

Brookfield, a noted cultural-ecological field geographer, has suggested that this practice of "borrowing" in no way detracts from geography's uniqueness, but actually highlights its nature as an integrative discipline. He very cogently expounds on this theme in his paper "The human frontiers of geography" (1964) and in a more recent publication (Brookfield, 1973). Others within cultural geography, on the contrary, are concerned that this "intellectual migration" will pull geography away from its true place in the "natural sciences" to a more limited and specialized focus in the "social sciences" (Marvin Mikesell, 1978). This debate, being part of a much larger and continuing controversy over "what is geography?" will probably never be totally resolved; what can be said for certain is that there is so much to be done in cultural ecology that at least until full implementation of a science of "human ecology" (Barrows, 1923) there will be plenty of room for input from a variety of disciplines.

Therefore, like Brookfield, this study assumes the posture that any methodology or theory (if we are really yet at that level of sophistication) that aids

in "explaining and understanding" cultural systems is worthy of utilization (Brookfield, 1973). Consequently, readers of this case study should not be surprised to find affinities in it with agricultural economics, agronomy, economic anthropology, physical geography, sociology, and other disciplinary endeavours.

The Microgeographic Approach:

Along with an interdisciplinary focus, this study shares another characteristic common to Brookfield's approach to cultural ecology: he holds the view that in-depth "microgeographic" (case study) field research should precede the development of macro-level "regional" theory (Brookfield, 1973). In Brookfield's view the most productive type of microgeographic research is one which utilizes a comparative analysis of a selected sample of communities as the method of achieving understanding of the cultural ecological dynamics of a regional system. By focusing on several communities in microgeographic detail, he feels one can overcome the methodological problem of attaining an overdetail d local understanding (restricting one's study to a single community) at the expense of universal comprehension; and yet also avoid the overgeneralization that often comes with a too broad regional approach - one which seeks universal understanding alone. In regards to the Sahel (this study's regional focus) it should be stressed that it is precisely due to the present paucity of both regional and particularly "microgeographic" understanding that massive international development and relief efforts have so often been out of tune with what peasants and pastoralists were thinking and/or with what needed doing (Sheets and Morris: 1974; Glantz: 1976; Richards: 1975).

In this research endeavour, three widely separated subsistence agricultural communities of differing ethnic/historical backgrounds, in different environmental situations were compared. The method appears to be useful, for it is felt that in this case a very adequate appreciation for the dynamics of Sahelian

semi-arid subsistence agriculture was achieved. Though the regional area of focus was in Upper Volta alone, the depth of coverage offered by the methodology here described, provided data and insights into agricultural problems which have applicability to the entire Sahel - far beyond the borders of Upper Volta alone, possibly to other tropical semi-arid environments as well.

#### The Ecological-Economic View:

A common denominator of many within the cultural ecological tradition is the adoption of the "ecosystem" model as the principal unifying theme. To Brookfield, "human geography" is the study of the "human ecosystem" rather than the study of the "areal differentiation of man's world" (1964: ). This perspective in geography has its origin in Barrow's 1923 call for geography to become the science of "human ecology". The relative merits and deficiencies of an ecological approach in cultural study (in both geography and anthropology) have been more than adequately dealt with in the literature, see Netting (1971), Vayda (1969), Mikesell (1970), Bates (1969), Steward (1955), Barrows (1923), Conklin (1957), Geertz (1972), Rappaport (1967 & 1968), Stoddart (1965 & 1967), Mayfield and English (1972), Eyre and Jones (1966), Fosberg (1963), Frake (1962). Suffice it to say, that even with its faults, the "cultural ecological" approach has yielded significant contributions, particularly in the study of subsistence economies. The fine works by the geographers Nietschmann (1973), Clarke (1973), and Knight (1974), plus others within anthropology attest to the merits of this approach.

Yet, as is to be expected, all theories and methodologies have their inadequacies and limitations. One of the problems characteristic of the "ecological school" has been a dangerous tendency toward what has been labelled "nutritional reductionism": the tendency to reduce the economic system to a simple nutrition-providing mechanism whose energy inputs and outputs can be measured quantitatively

much like that done in plant and animal ecology. Scott Cook, an economic anthropologist has stated the problem in these words:

"From the perspective of economic anthropology, one of the most frustrating tendencies in ecological anthropology literature is the implicit reduction of economics to nutrition and of production to the creation of calories, rather than the creation of use and exchange values through the appropriation and transformation of natural resources" (Cook 1973:849)

The point he is making is that in analyzing a cultural system's adaptation to a specific environment we should not only be concerned with the tangible quantitative physical-ecological relations in a system, but the less tangible qualitative social-economic relations as well. For example, a pastoralist's herd can be studied in terms of its direct contribution to the survival of the herder in terms of protein and calorie production per animal unit. But what are the functions of cattle-raising and the "way of life" associated with it in terms of maintaining individual and collective solidarity and psychic satisfaction? Paul Riesman who has looked at this problem in his very fascinating book Freedom in Fulani Social Life, (1977) shows that the "world view" (cosmology) and the very concept of "self" (personal freedom) in Fulani society is closely tied to and influenced by the economic pursuit of herding. A narrow "nutrition-oriented" study would have overlooked the deeper "human" meanings of economic activities and functions. For these reasons, this study attempts to integrate the ecological and economic perspectives in a "holistic" manner that does justice to man as man the thinker as well as man the organism.

One of the most thought provoking ecological/economic studies in recent times was a study of an agricultural region in northern Canada by John Bennett (1969). His work was innovative in two major respects: one, it was one of the first studies of an ecological nature not done in a "primitive" non-western society, and secondly, it was one of the first to not utilize the "ecosystem" paradigm as its unifying theme. Though the present study is of the more traditional

type, in that it focuses on a non-western socioeconomic system, it does follow in Bennett's footsteps by the non-utilization of the "ecosystem" model and in turn has selected "adaptation" as the major theme.

To John Bennett, the basic process operative in human societies which best explains ecological/economic relationships is "adaptation": he specifically identifies the core of adaptation as "'coping' behaviors-problem solving, decision-making, consuming or not consuming, inventing, migrating, staying" (Cook 1973:849). In other words, the basic elements of "adaptation" in human societies are "behavioral" - a function of man's unique nature as a "choice-making" organism. In Bennett's work he identified within "adaptation" two principal components:

'...first, the notion of adaptive strategies, or the patterns formed by the many separate adjustments that people devise in order to obtain and use resources and to solve the immediate problems confronting them; second, the idea of adaptive processes or the changes introduced over relatively long periods of time by the repeated use of such strategies or the making of many adjustments (quoted in Cook, 1973:849).

This study does not attempt to make explicit the distinction between "strategies" and "processes" of adaptation as did Bennett (it was not felt to be really a necessary distinction for the objectives of this report) yet the conceptualization is a good one.

The decision to not utilize the "ecosystem" paradigm as the unifying theme is based on the following: Those who have attempted to explain and understand another culture by means of creating and describing an abstract "system", often produced a cohesive, meaningful model which looked and sounded beautiful (at least to the researcher), but in the end did not conform to reality. As Clarke states: "how can (the researcher) be certain what the relevant components of (a) system are, or even that in reality there is a system? (1973:203).

Furthermore, many who use the "systems" approach are led to view the culture under study as a "mechanically equilibrating natural system" whose normal tendency is to equilibrium, stasis, and harmony. Unfortunately, this perspective can

ignore the possibility of radically disquilibrating change occurring in societies of either an "adaptive" or "maladaptive" nature. Man, with his unique ability to choose, can deliberately destroy his own environment and means of survival, or he can conserve and restore it. This "human" trait doesn't seem to fit into a naturalistic "systems" perspective.

### "Folk" Ecology:

Moreover, whether the abstract "system" created is actually the same as that perceived by the "insider" to the host culture is an even more serious issue. Frake (1962), Rappaport (1968), Burling (1964), and others have discussed this quite extensively. The outcome has been the development of an alternative approach to the study of cultural ecological systems: "ethnoscience". The latter perspective utilizes a complex linguistic research tool (componential analysis) to get "in" the host subject's head, hopefully thus allowing the scientist to distinguish between what is "perceived" to be reality and what it actually is, in the objective sense. The object of this ecological method is to describe what people "know" about nature, what is their own "folk ecology" (ethnoecology), and furthermore how people use this knowledge to get along in the world.

Understanding the Sahelian peasant's "folk ecology" has more than just theoretical interest; it is also immensely practical: for instance if one can learn the way local people classify their environment, this will suggest what is "perceived" to be important to them, what they define as a "resource", and, even more important, what they perceive to be the "risks" of making a living in that environment. Richards has clearly expounded on this theme in these words:

...For it is when we study the principles governing the naming and classification of elements within the environment that we begin to understand how the traditional farmer conceptualizes his world. These

classificatory principles not only help us to see things as he sees them, but also provide an insight into the fundamental process of linguistic and symbolic coding which permits a society either to replicate or to change its structure and culture from generation to generation (Richards 1975:106) (see also Levi-Strauss 1962, 1963).

Richards further points out:

Traditional classifications of plants and animals are no whit less logical than those of the academic biologist for stressing "eatability" rather than philosophical principles derived from "great chains of being" or theories of the evolution of species. It is possible, however, that the classificatory logic of village self-sufficiency may be at odds with the requirements of economic development. Whatever the case - whether the traditional terminology can be expanded to meet the needs of the new situation or whether the farmer must learn a new set of terms and categories - it is evident that any deliberately induced programme of change must start with a thorough working knowledge of the traditional system of terminology (cf. Conklin 1954). This calls for a certain amount of flexibility and sympathetic collaboration between linguist, agronomist, and ordinary farmer (Richards 1975:107).

In other words, Richards feels that innovations in agriculture (if they are to be culturally relevant and useful) will be best received and understood, if they fit into the local perception of reality. Thus inclusion of "ethnoscience" research into any "development" oriented project seems valuable.

There is only one practical problem with most ethnoscience research: it is highly specialized and requires linguistic skills not available to most applied researchers. So how does one do the traditional time-consuming work of studying the economic patterns of a people and all its environmental interrelations, and also have time for studying the "folk" ecology? In this study, a compromise with theoretical purity had to be made (which in itself is not an unusual happening in field research). An attempt was made at every opportunity to elicit local terminologies for soils, plants, and other environmental factors, and where possible their correlation with scientifically ascertained evaluations of the environment. But in no way can it be assumed that this report is at the level of an ethnoecological treatise. Rather it is at a rudimentary scale, exemplary I feel of what is feasible for the average applied non-

linguistically trained student of subsistence communities. And it is illustrative of how this type of knowledge can increase understanding of cultural ecological systems.

Even minimal attention to "folk ecology" is worth the effort, if for no other reason than the value it has as a "rapport-building" device between the outsider and the host peoples one is working with. Peasants are always interested in talking about what they "know" and open up to someone who genuinely shows interest in the way local people see their world. This is probably ethnoecology's principle contribution when practiced at a rudimentary level.

Summary of Theoretical Perspective:

To sum up, the theoretical perspective portrayed in this study, reflects a blending of influences from several distinct disciplinary and theoretical outlooks. This should in no way detract from, but exemplify the "holistic" nature of geography: it is ecological, but without utilizing a "systems" approach; it attempts to integrate economic awareness with an "inside" view of Sahelian environments (the "ethnoecological" perspective); and it utilizes a comparative microgeographic approach to achieving regional and local understanding. Furthermore, as this research project was part of an over-all applications-oriented USAID sponsored program (footnote 2 page ) it was inevitable that an applied slant should predominate. Finally, this synthesis of theory and experience should be seen as being primarily the product of my personal encounter with an unfamiliar culture, in a strange and hostile environment complicated by the usual bureaucratic hassles common to fieldwork situations everywhere. Therefore the errors both in theory and method are all mine. Nevertheless, I do hope this case study will aid in furthering knowledge and understanding of Sahelian subsistence systems and the semi-arid tropics in general.

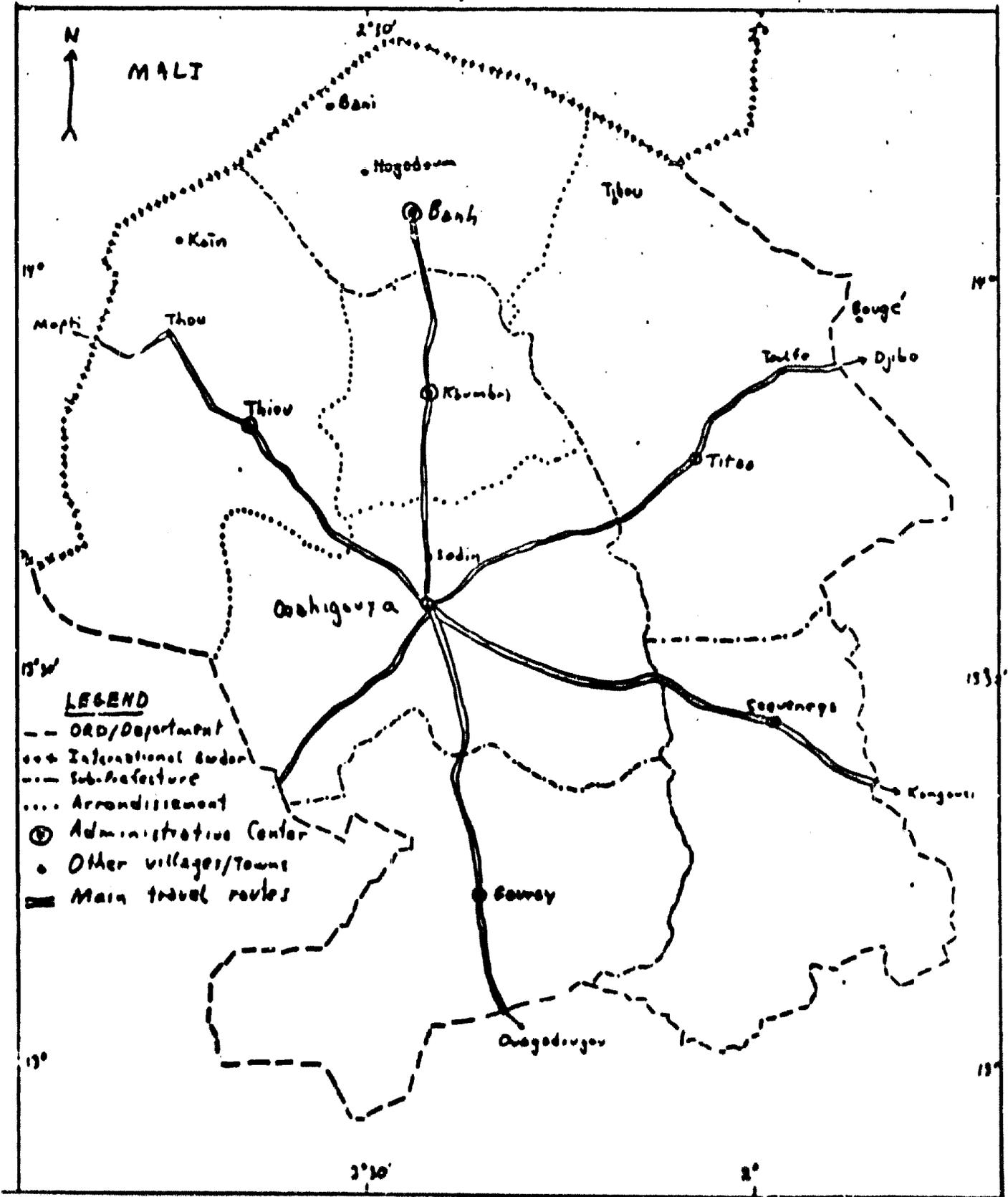
## CHOICE OF FIELD STUDY SITES

The need to sacrifice theoretical purity for practical considerations in the choice of fieldwork study sites is well understood by field researchers. In this case, the region chosen was Yatenga: the northwest administrative and development district (ORD)<sup>5</sup> of Upper Volta (V. Figure 1.1 page ). The boundaries of this region correspond even today with one of the three ancient kingdoms of the Mossi. The district center, Ouahigouya, is the fourth largest town in the country and is linked by a reasonably short all-weather dirt road to Ouagadougou, the national capital (Figure 1.2 page ). Strong consideration was given to other localities such as Dori, the capital of the Sahel ORD, and Djibo, a subcenter of the latter. Both of the latter areas are much drier and deeper into the true Sahel, which made them very appealing from some perspectives, but their relative isolation from contact with other areas made Ouahigouya preferable. Ouahigouya's location proved to be strategic for several reasons (V. Figure 1.1). It essentially straddles the 700mm isohyet, which roughly corresponds with the Sudan/Sahel climatic boundary. From it easy access to diverse geologic, topographic, and biotic regions was possible. It is on one of the principal trading routes between the drier Sahelian regions to the north, and the wetter savanna regions to the south. And it contains a great diversity of livelihood patterns and ethnic groups i.e. sedentary farmers (Dogon, Samo, Kurumba, Mossi), semi-sedentary and nomadic herders (Fulani, Touareg), former slaves (Rimaibe, Bella), and others. Furthermore, the complex, and reasonably well-documented culture history of the region presents a unique opportunity to view human adaptation in a time-dimension not easily attainable in other areas, see Michel Izard (1958), Annie Marie Schweeger-Heffel (1975), Peter Hammond (1966), Paul Riesenman (1977).

After reconitering the entire region north of Ouahigouya (including visits to Djibo and Dori), three villages were selected for in-depth cultural-ecological



Figure 12 location Map of Yatenga, Upper Volta



analysis: Sodin, a densely populated Mossi sedentary farmer settlement close to the regional center of Ouahigouya. Toulfa, a more isolated and traditional Kurumba settlement, also composed primarily of sedentary farmers, but as it borders the southern limit of dry-season Fulani pastoral migration it illustrates very strongly the symbiotic inter-actional pattern of farmers with semi-nomadic Fulani herders. The last, Banh, was a totally Fulani herder-dominated settlement located on one of the ancient fixed dune systems common to this portion of the Sahel. In Banh the farming is primarily conducted by a former herder slave caste - the Rimaibe, while the semi-sedentary (transhumant) Fulani concentrate on herding (though they do some farming as well). Between these three villages most agricultural livelihood patterns common to Sahelian Upper Volta could be observed. Furthermore, each village was in a significantly different habitat affording substantial opportunities for cross-correlation with a wide diversity of cultural-ecological variables.

Prior to analyzing the social and economic life of the villages in question, it is first necessary to present a regional overview of the cultural and physical-ecological characteristics of the Sahel as a whole, after which will be presented a look at their sub-regional expression in Yatenga. With this background knowledge the local expression of Sahelian subsistence agriculture as seen in the chosen village sites will become more meaningful.

#### THE SAHEL. IN RELATION TO THE WORLD'S DRY-LANDS

##### The Diversity of Dry-lands:

The world's dry-lands have always presented a major challenge to man: both as an object of study and an environment to cope with. Man's history has been inexorably intertwined with dry-lands. Yet, many still think of these regions in relatively stereotyped ways: barren expanses of drifting sand, occasional exotic oases with their irrigated date palms, petrodollar-rich "oil sheiks"

ruling obscure desert kingdoms. But dryland regions include a much larger diversity in livelihood patterns and ecological characteristics than this.

Perusal of any map of the world's drylands points out that they not only cover a major portion of the earth's surface, but they are found in almost all major world regions: they not only include "extremely arid" areas like the Atacama Desert of Chile where rain seldom comes, but they also include "dry sub-humid" areas like the Sudanic zone in West Africa or portions of the Deccan Plateau in India. Some drylands are "cold" (Central Asia), others "hot" (the Sahara); some are "tropical"<sup>6</sup> (Northeast Brazil) while others are "extra-tropical"<sup>7</sup> (the Basin and Range Desert of <sup>(the Western North America)</sup> ~~the Basin and Range Desert of~~). Due to this wide diversity of characteristics in drylands, defining their limits and their subdivisions has long been a controversial scientific endeavour.

#### Need to Study the Semi-Arid Lands:

Of all the dryland areas, the "semi-arid"<sup>8</sup> lands are probably the least understood, and today they are of major research interest to many disciplines (Arnon, 1972; Cannell and Hall, 197<sup>9</sup>). "Extra-tropical" semi-arid lands in North Africa and the Middle East have received considerable attention in the past, but the "tropical" semi-arid lands, on the contrary, have not been as well studied, in spite of the fact that a large portion of the world's population resides in these environments i.e. the East African grasslands or the Deccan Plateau of India. Considerable confusion exists in the terms used for these areas, making uniform understanding very difficult. One finds terms such as "wet-and-dry tropics" (Keay, 1959), "monsoonal grasslands" (Whyte 1968), "savannas and Castings" (Hills 1973) and "tropical grasslands and steppes" (Church 1974). None of these terms necessarily coincide, for they were formulated with different purposes in mind and based on field experiences from diverse areas of the globe.

Without going into the complexities of dryland classifications (Bowden 1978) let us be satisfied with the following operational definition of "semi-arid" as presented by the latter:

The concept of semi-aridity can best be related to crop plants and pasture. The dry boundary of the semi-arid tropics should lie on the edge of the area where production of rain-fed annual crops is not possible during a majority of years, even though steps are taken to conserve and maximize available moisture. However, satisfactory pasture is regularly produced over most of the surface, and dryland farming can be practiced in occasional years at edaphically favored spots, such as regions of runoff from exotic streams. The humid limit occurs where droughts do not substantially limit the productivity of crops in a majority of years but dry-farmed crops can and do fail due to occasional drought. Positive correlations between the amount of precipitation and crop yields occur at the humid boundary (Bowden 1978: ).

A peculiar trait common to the tropical semi-arid areas is that they often have to contend with the environmental problems characteristic of both humid and arid areas, yet they may have few if any of their assets, i.e. exotic rivers like the Nile and other regions, or reliable rainfall as in the tropical rain forests. The farmer in semi-arid regions must not only cope with frequent lack of sufficient precipitation (an arid problem), he also must cope with occasional periods of too much water - high intensity rainfall with associated heavy erosion (a humid land problem). Seasonal variation in the climate from an almost totally desert-like climate to monsoon all come within the same year, making these tropical semi-arid regions not only risky from the point of view of agriculture, but also at certain seasons, quite unattractive and uncomfortable to live in.

#### The Sahel - A Major Semi-Arid Region:

One of the major semi-arid transition areas in the world is the Sahel of West Africa - that narrow zone separating the dry Sahara to the north from the forests and humid savannas to the south (v. Figure 1.3). The term -Sahel- is of Arabic origin meaning "shore": a term which connotes a transitional type of habitat - an "ecotone" in ecological terms. Politically and administratively the

Sahel has come to refer to those countries bordering the southern edge of the Sahara which suffered greatly in the devastating 1968-1973 drought: Mauritania, Senegal, Mali, Upper Volta, Niger and Chad. This broad usage, unfortunately, has obscured its ecologically-based parameters (See the next section for a more precise definition of the "Sahel").

Perusal of Figures 1.3 & 1.4 Page 19 shows that in West Africa there is a generally uniform south to north (zonal) transition of climate and vegetation starting with mangrove and rainforests on the Guinea coast, Guinea and Sudan savannas in the intermediate zones, and Sahel and Saharan zones to the north. Although this generalized zonal picture of the West African environment holds true on the broad regional level, it tends to obscure considerable sub-regional variation in geologic, topographic, biotic, and, even more significant, anthropogenic factors, which have great effect on the livelihood patterns of individual communities and the "adaptive mechanisms" they have developed for survival.

The influence of "anthropogenic" factors in the West African savannas and steppes cannot be overstated: through fire, soil erosion, selective vegetation use, and plant domestication, man has so strongly altered these ecosystems that some ecologists doubt very strongly that one can speak of "natural" ecological zones in this area (v. Ajejuwon: 1976). In terms of the length of occupation by man (both in historical and prehistorical times) it is these savannas and steppes of Africa which have felt the impact of man the longest, as attested by archaeological research in East Africa and other areas. Long before Europe began its colonial penetration from the coasts, the savannas and steppes were centers of extensive African Empires like Kanem-Bornu and Mali: kingdoms whose political and commercial ties extended over most of northern Africa. Their influence as transmitters of cultural, political, and technological ideas from

FIGURE 1.3:

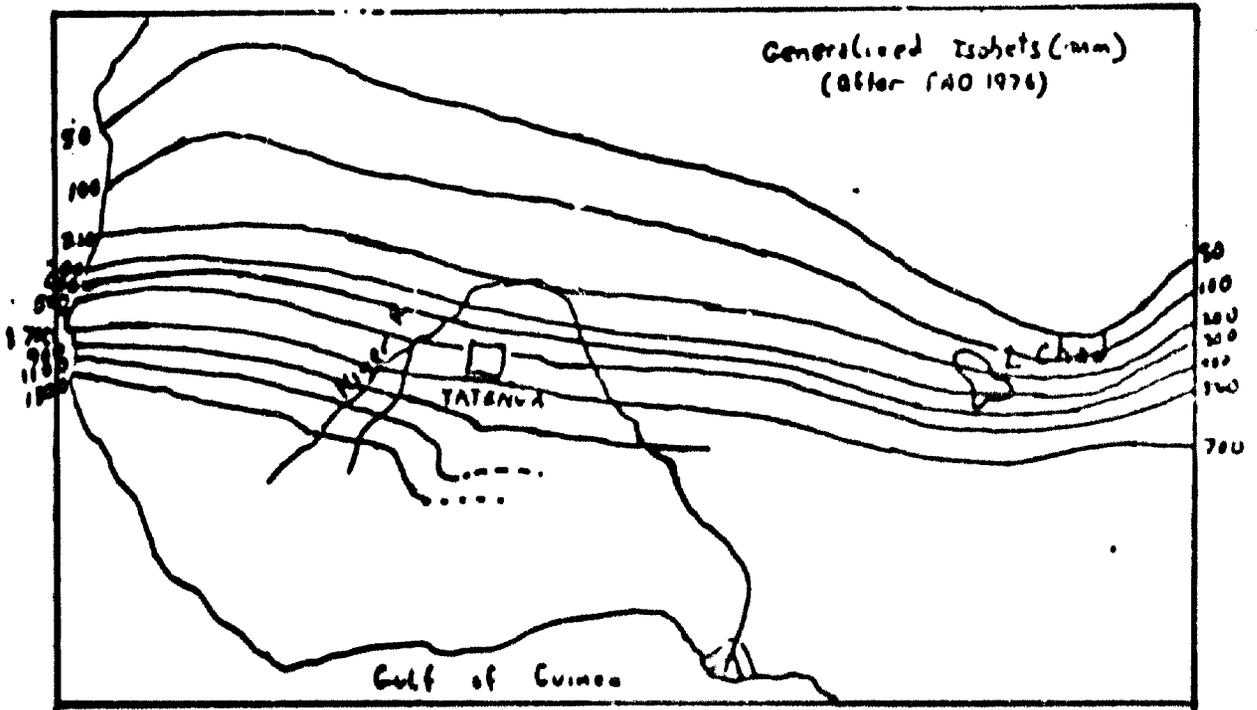
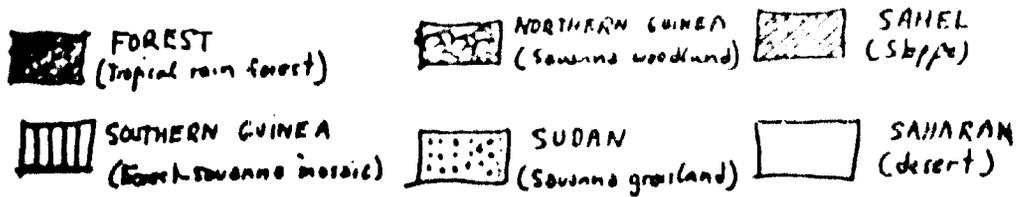
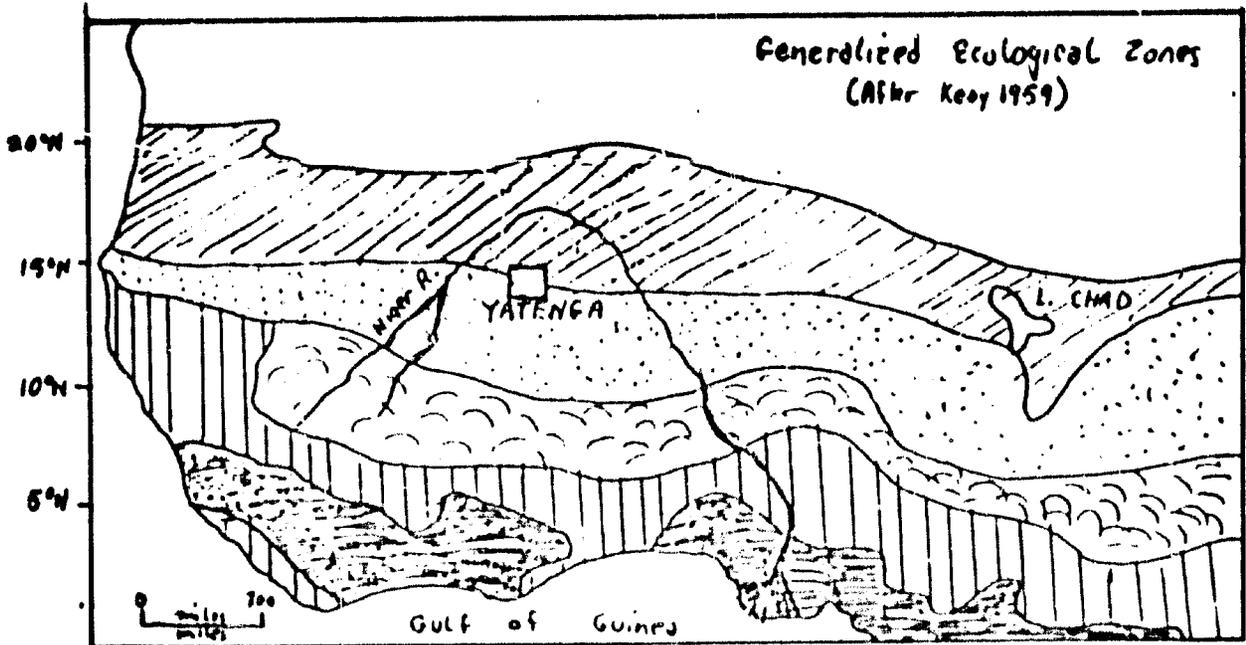


Figure 1.4

Egypt, North Africa, and other areas, has been very significant to the region's history. Furthermore it is in these same savannas that the Neolithic revolution in West Africa first occurred i.e. the domestication of millet. The Sahel, therefore, as one of the largest "semi-arid tropical" zones in the world where there has been a long history of interaction with man, is an ideal place to study the "cultural ecology" of semi-arid tropical subsistence agriculture.

#### Cultural-Ecological Parameters of the Sahel:

The most common parameter utilized in delimiting the Sahel by ecologists is climate. As Bradley points out, "At the largest scale the Sahel can be separated into three climatically determined zones with associated vegetation formations (v. Table 1.1 page 11 and Figure 1.5 page 12). These zones are, of course, defined by more or less arbitrary boundaries, the whole system being a transitional zone between the desert to the north and the more humid savanna to the south" (Bradley 1977: 35-36). Most authorities would agree that the 700mm to 100mm rainfall zone encompasses the "core" of the Sahel and includes its humid and dry boundary transition zones.

Le Houerou (1976) has analyzed some of the major classifications of the West African landscape and combined the ecological dimensions (i.e. climate) with the cultural elements (i.e. land use and livelihood) into one classification schema (v. Table 1.2 page 23).<sup>9</sup> Notice, that although Table 1.2 shows part of the Sahel as being within the "semi-arid" area, as defined by Bailey <sup>(1979)</sup> it is not coterminous with it. The same can be said for Meigs' delimitation of the "semi-arid" zone (v. Figure 1.6 page 24).

Boulet, a French soil scientist with extensive field research experience in West Africa, points out that when one defines the boundaries of the Sahel zone on the basis of "agroclimatological factors and their expression in soils and vegetation" <sup>(v. Figure — page —)</sup> the Sahel boundary <sup>as he defines it</sup> should be much more restricted on the "humid" limit than the more broadly defined "semi-arid" zone delimited by Meigs and Bailey.

Table 1.1

Sahelo-Sahara

- Climate:** extremely variable rainfall, but nominally less than 250mm; rainfall season lasting from mid-July to mid-September.
- Soils:** largely undifferentiated and poorly developed; classified by Aubert (1965) as sub-desertic or brown sub-arid.
- Vegetation:** steppe of scattered perennial tussock grasses: Aristida pungens on the desert margins, Panicum turgidum in the more humid south; scattered low trees and shrubs of Acacia tortilis, A. ehrenbergiana, Maerua crassifolia.

Sahel

- Climate:** rainfall more reliable though still highly variable, between 250mm and 400/450mm; July to September.
- Soils:** brown to red-brown sub-arid.
- Vegetation:** prairie (Audry & Rossetti, p. 1962; Rattray, 1960) of annual grasses: Aristida mutabilis, A. adscensionis, A. funiculaga, Cenchrus biflorus, Eragrostis tremula, Schonefeldia gracilis with scattered tree cover of Acacia raddiana, A. senegal, A. seyal, Balanites aegyptiaca, Commiphora africana, Zizyphus mauritiana, Boscia senegalensis. Possibly a grazing subclimax (Rossetti, 1965; Whyte, 1968) wet season grazing lands.

Sahelo-Sudan

- Climate:** rainfall sufficient for reliable agriculture; 500/450mm to 550/700mm, mid-June to early October.
- Soils:** ferruginous tropical soils unleached to slightly leached.
- Vegetation:** open savanna dominated by Combretum glutinosum, with Cuiera senegalensis, Grewia spp; Adanaonia digitata, Argemoneis leiocarpus, Sterculia setigera, Pterocarpus spp; Terminalia spp. Grass cover of dense perennials: Andropogon gayanus, Diheteropogon hageruppi, Hyparrhenia spp. with annuals such as Eragrostis tremula, Aristida mutabilis, Schizachyrium exile, Ctenium elegans, Pennisetum pedicellatum; dry season grazing areas.

**Note:** This table is adapted from Bradley, 1977: 35-37.

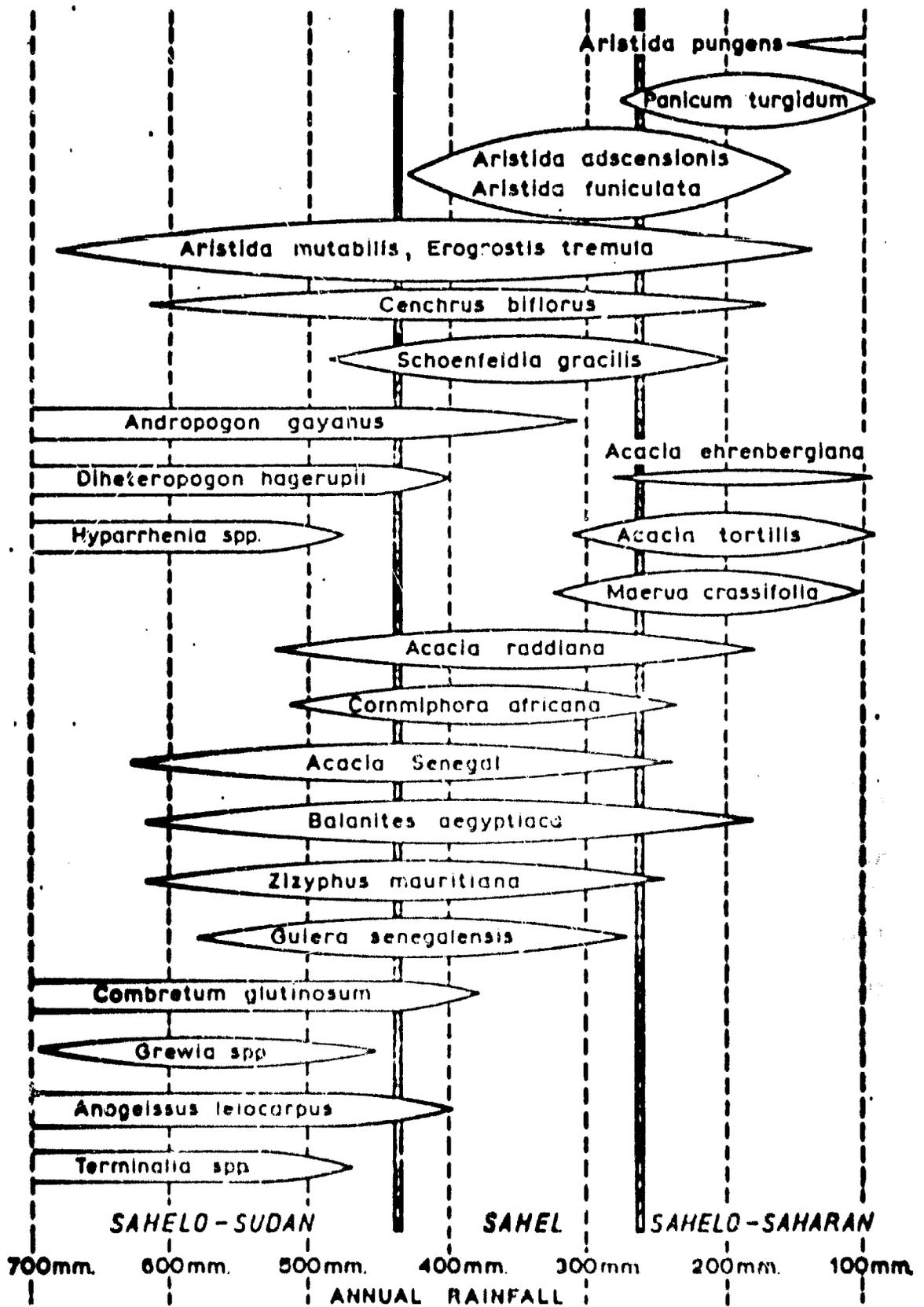


Figure 15 GENERALISED CLIMATIC ZONATION OF PRINCIPAL SAHELIAN PLANT SPECIES

Table 1.2  
LANDSCAPE COMPONENTS OF THE SAHARANO-SABELIAN ZONE (4)

ANNUAL RAINFALL (mm)	ECOLOGICAL ZONE(S)	PHYSICAL LANDSCAPE	VEGETATION	SOILS(1)	LAND USE (IRRIGATION EXCEPTED)		AGRO-CLIMATIC BOUNDARIES		ANNUAL RAINFALL (mm)
					ANIMAL REARING	CULTIVATION	BAILEY(2)	BOULET(3)	
50	SABARAN		None except scattered plants in depressions	Lithosols Vertisols	Large scale nomadism (~ 300km)		ARID	SABARAN	50
100									100
200	LAHLO-SABARAN	Stoney, Sandy-desert, dunes	Widely scattered	Regosols (Dunes)	Pastoralism with camels and sheep		320mm		200
400	SABELIAN CORE		Open steppe	Arenosols Vertisols	Nomadic transhumance (~150km) pastoralism with camels & cattle				400
600							SEMI-ARID	NORTHERN	600
800	LAHLO-SABELIAN	Patches of dunes in eroded soils with depressions (bas-fonds) Temporary swamps	Wooded steppe	Gleysols Solonchaks (Solonetz) Fluvisols Luvissols	Semi-sedentary pastoralism with camels and cattle	No diversification; Nibe, millet, short cycle groundnuts			800
1000							1100mm	TRANSITION	1000
1200	SODHARTAN		Open savanna	Fluvisols Vertisols Luvissols Gleysols	Sedentary pastoralism Limit of endemic glossina	Little diversification; millet, sorghum, groundnuts			1200
1400		Eroded slopes (inverted relief)	Wooded savanna	Nitrosols		Wide diversification; long cycle millets & sorghums, groundnuts, cotton	SUB-HUMID	SOUTHERN	1400
1600	GUINEAN		Forest/Savanna mosaic		Ferralsols Luvissols				Rice in heavy soils, mango orchards, & other crops above

- Notes: 1) Soil classification (FAO system).  
 2) Bailey's classification of semi-arid climates is discussed in detail in (Hall & Conwell, 1979:99).  
 3) Boulet's system is deduced from both agro-climatic data and soil/vegetation field observations (see Boulet: 1976).  
 4) The entire table is a modified version of Le Houerou's, 1976: \_\_\_\_\_.  
 5) The FAO study by Le Houerou has labelled the entire 50-1500mm zone in West Africa; Saharano-Sabalian (Le Houerou: 1976).  
 6) Terms for "dunes" used most commonly by FAO and other scientists.

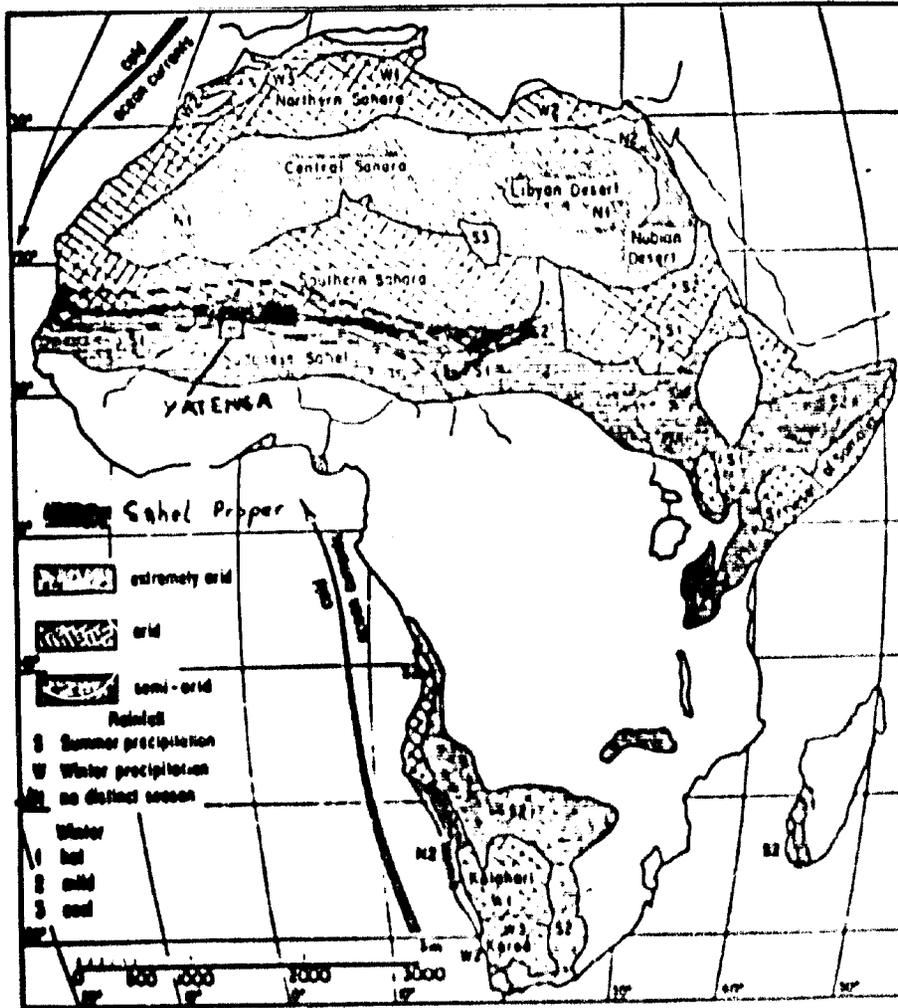


Figure 1.5 Map of the arid and semi-arid regions of Africa. (After Meigs (1953): by courtesy of the United Nations Educational, Scientific and Cultural Organization.)

Notice that in Table 1.2 Boulet restricts "Sahelian" or "Northern" zone to the under 600mm rainfall area, he calls the 800mm-600mm area a "Transition" zone, the 800mm-1200mm zone "Intermediate", and the 1200mm-1500mm belt "Southern". Observation of environmental conditions relating to "drought risk" and natural vegetation formations appear to confirm Boulet's delimitation of the Sahel boundary.

The Crucial "Sahelo-Sudanian" Zone:

In spite of the varying opinions on boundary locations, most Sahelian authorities agree that a key boundary is the 400mm-450mm isohyet, particularly as it relates to agriculture. North of that line, except for unusual edaphic circumstances, permanent "rain-fed" agriculture is nearly impossible, and consequently pastoralism is the dominant way of life. South of the line agriculture becomes possible, but the risks from drought are extremely high until one passes the 700mm isohyet. Thus the area between the 700mm-450mm isohyets (the "Sahelo-Sudanian" zone) is the crucial "high risk" portion of the Sahel in terms of rain-fed agriculture. And it is on this zone that this report focuses.

The importance of the "Sahelo-Sudanian" zone for research and development lies in more than just its being the most prone to severe drought and famine (O'Keefe: 1974). Several characteristics set it apart from other West African areas:

1. This zone represents the effective outer limits of rain-fed agriculture in West Africa, FAO:1976.
2. It is in this zone where pastoral and arable economies attain their greatest interaction, and it is here where increasingly the signs of stress in long standing traditional herder-farmer symbiotic relationships are becoming apparent. The potential for conflict is definitely highest in this zone, (Barral, Benoit, Calais, and Riesman).
3. The Sahelo-Sudanian zone is still not well integrated either politically or economically into the national life of the states in which it occurs. Relative inaccessibility and administrative peripheralness make relief activities in time of crisis and general economic development less effective and painfully slow, (Glantz and O'Keefe).

4. "Desertification" in all its forms is most severe in this zone. Eolian erosion, labelled by the media as the "advancing sands of Sahara" is in spite of journalistic hyperbole increasingly a fact in the most heavily impacted areas. This zone, being the transition between the perennial and annual grass regions, is heavily utilized for grazing activities. Inadequate grazing controls and rapid animal population growth and migration have led to serious over-grazing, Boudet ( ), Barral ( ), and O'Keefe (1975).
5. This is a zone of rapid human population growth as well, stemming from high rates of natural increase and increased migration from overpopulated farming lands to the south and displaced nomads coming down from the drier northern regions. The opportunity for conflict and environmental disaster are clearly present, Gallais, (1975), and Marchal, (1978).

In summary the Sahelo-Sudanian zone and the people in it are facing a very bleak future, both in terms of long-term economic development and ecological stability. Even now it has a high potential for large scale human disaster - even greater than that of the much publicized 1968-1973 drought and famine. The need for both "understanding and explanation" seems obvious.

## FOOTNOTES

1. Agriculture here includes pastoralism as well as subsistence and cash-crop farming. Though the major proportion of agriculture in the Sahel is still primarily subsistence, "cash-crop" agriculture is increasing in scope and significance.
2. MUSAT:era is the acronym for (Moisture Utilization in the Semi-Arid Tropics: summer rainfall agriculture). It refers to a U.S.A.I.D. sponsored 211-D grant project awarded to the University of California, Riverside whose purpose is to improve the university's research and applied capabilities in regard to the agricultural development problems of the semi-arid tropics, particularly the West African Sahel zone. This study was funded and carried out under the sponsorship of MUSAT (for further information contact Dr. Glen Cannel: Program Director, Department of Soils and Environmental Sciences, University of California, Riverside, Riverside, California 92502).
3. "Cultural ecology" is here taken to be that type of geographical and anthropological research endeavour which attempts to describe (usually through in-depth case studies of single communities) the sociocultural and economic strategies and techniques developed by specific cultures over long periods of time to "cope" with their social and physical environments. The founding of this research methodology is generally attributed to Julian Steward, who gave the most definitive description of the "tool" in his work Theory of Culture Change, 1955. Many geographers and anthropologists have been active in this type of research.
4. "Subsistence risk" is here defined as any factor or variable that either limits the subsistence farmer's ability to fully exploit his environment and make a living and/or any factor that diminishes the productivity and dependability of his resource base. Frequent drought is an example of a major "environmental" risk of farming in the Sahel, while labor supply fluctuation due to sickness, accident, migration of family members, and so on, is an example of a "socioeconomic" risk. Understanding the nature of the risks as perceived by the farmer is crucial to understanding the reasons for his decision-making strategies and actions. The concept of "subsistence risk" is not new, see Porter (1970) and Allan (1965), but it is one that still merits such refinement and research.
5. An ORD is (in French) Organisation Regional de Developpement or Regional Development Organization. It corresponds (in geographical terms) to the "state" level of administrative-political structure. Each ORD plans and coordinates all "development" related activities within its region including those of the ministries of agriculture, health, resources, water, animal husbandry, etc. The scheme puts more power at the regional level and thus attempts to decentralize economic development activities, an attempt to counter the over-centralized control of capital cities common to many "developing" nations.

6. The term "tropical" is here used in the sense of temperature (places essentially frost-free) rather than its astronomical meaning in relation to the Tropics of Capricorn and Cancer.
7. "Extratropical" is used here in the astronomical sense -- areas poleward of the tropics (in most cases they are also areas experiencing frosts during some portion of the year).
8. "Semi-aridity" as a term suggests that it refers to a "transitional" environment between "arid" and "humid".
9. Table      in the Appendix summarizes some of the most common ecological classifications on which Table II is based. Table      in the Appendix offers a brief summary of other climatological classifications utilized in the dry-land areas of Africa.

**BEAN/COWPEA - CRSP REPORT****May 19 - June 15, 1979****Visit to Kenya, Tanzania, Malawi, Botswana, Zaire and Nigeria****Glen H. Cannell, M.J. Silbernagel and W. Mwangi****A. Kenya****1. USAID Mission****Visited:****Wilbur Scarborough, Agricultural Research Advisor****Jack Slattery, Health & Nutrition Specialist****Linda Meyers, Nutrition Specialist, Lecturer, Cornell University**

Discussion of the agricultural program centered on new USAID projects (expected initiation in late 1979) that relate to grain legume crop production. These projects are part of a much larger program aimed at the semi-arid regions in the East Kenya provinces of Machakos/Kitui with rainfall in the range of 500-750 mm. These projects are in collaboration with FAO and the Government of Kenya, and one of the crop areas receiving special emphasis is production of beans, cowpeas and pigeon peas. This is part of a large, integrated food crops development program for the semi-arid regions and the work would be centered at the Katamuni Dryland Research Station.

Other discussion areas were concerned with health and nutrition of present programs, awareness studies covering nutrition problems, the role of women in food production, intervention type programs and impact studies on nutrition and economics with development of agricultural programs in the semi-arid regions.

At this point in their programs it is believed they are aware of many nutritional-food constraints for different crop production areas in Kenya, including the nutritional weaning problems associated with women in the work force.

Because of the time constraints on the new projects dealing with beans and cowpeas, USAID did not identify specific areas where the CRSP may interface, supplement or complement their planned programs, although it appears to give primary emphasis to maize, while the FAO project includes maize, cowpeas and pigeon peas. Beans are not emphasized because the projects are aimed at the semi-arid lands.

2. Nairobi University

Visited:

Dr. D. M. Mukunya, Senior Pathologist  
Dr. D. Magogi, Chairman, Plant Sciences Department  
Dr. S.O. Kaya, Soil Microbiologist  
Dr. R. S. Pathak, Plant Breeder  
Dr. H. Smali, Soil Chemist  
Prof. C.N. Karua, DEAN of Faculty  
Dr. D.I. Gomez, Nutritionist

W. Mwangi arranged through Dr. D.M. Mukunya to visit the Kabete campus where the Faculties of Agriculture are located. Individual visits were made with Dr. Mukunya and Dr. D. Magogi, Chairman of the Plant Sciences Department, and a conference with several staff working on an interdisciplinary Integrated Grain Legume Improvement program (beans and cowpeas). These discussions and consultations were very fruitful in determining research directions and program objectives.

The broad approach in their research program on beans and cowpeas offers excellent CRSP interfacing potential in many areas of their program (cropping systems, breeding, pathology, entomology, nutrition, microbiology, soil fertility and with Al toxicity in acid soils). An integrated program on production of beans and cowpeas is broad, involving plant breeding, plant pathology, agricultural entomology, soil chemistry, microbiology, agronomy and nutrition.

The cowpea improvement program is now in its third year. The research program is supported by the Research Division of the Ministry of Agriculture through provision of land at research stations and personnel support for assisting and conducting experiments. A recent agreement between the University and the Scientific Division of the Ministry to carry out cooperative research on legume crops for the semi-arid regions is assurance that the research program at the University is viable and will continue to be an effective research unit in legume crop production.

General areas that would appear to be most fruitful for improving their bean and cowpea programs are:

1) pass-through funds for laboratory supplies and equipment, and back-up technical personnel support for laboratory studies;

2) training of students both in M.S. and Ph.D. programs in the various areas of bean and cowpea research being carried out in the program;

3) a scientist exchange program whereby the University of Nairobi staff could spend 6 months to a year with a counterpart in a U.S. university working on beans or cowpeas, or a similar exchange where U.S. scientists would spend similar periods of time at Nairobi University. The effectiveness of an exchange program would lie in the ability to work out arrangements whereby the relatively small staff at Nairobi would not be decimated or decreased in size as they have at present a heavy teaching load;

4) short term visits of several weeks by U.S. scientists to work cooperatively on bean and cowpea disease and insect problems, and possibly other related problems in production would be beneficial;

5) exchange of germplasm for drought resistance, insect and disease control and other constraints would be very useful in their program, as well as in U.S. programs. Linkages have been made with IITA for receiving germplasm and good progress has been made by the cowpea plant breeder in selecting 3 superior cowpea lines from mixed Kenya genetic material.

The following University of Nairobi staff are working with the Integrated Orsin Legume Project called the Plant Protection Program: (see attached to report)

Dr. D.M. Mukunya and Dr. J.P. Singh, Fungal and Bacterial Diseases of Beans  
in Mixed Cropping Systems

Dr. E.M. Gathuru, Plant Virologist

Dr. S.O. Odiru, Crop Physiologist

Dr. D.N. Ngugi, Crop Physiologist/Weed Scientist

Prof. C.P.M. Khamala, Dr. M. Muska, Dr. S. Karel, Entomologists

Dr. S.O. Kaya, Microbiologist

Dr. Seali, Soil Scientist

Dr. R.S. Pathak, Plant Breeder

### J. Scientific Division of the Ministry of Agriculture

Visited: Dr. B.K. Majiu

We were not able to make arrangements to visit with the Director of Research, Dr. D.K. Thiarou of the Ministry of Agriculture. However, we did meet with Dr. Majiu, Chief Scientific Officer of the Scientific Division of the Ministry.

He confirmed the interest conveyed to us by the USAID Mission that their primary interest is in crop production in the semi-arid regions of East Kenya. He mentioned the 5-year program planned to begin in late 1979 and the Ministry of Agriculture's full support behind the program.

This program is directed to the small farmers in that region, and one of the primary objectives deals with improving nutrition by concentrating on production of legumes, particularly cowpeas and pigeon peas, which can be grown successfully in the semi-arid regions. Strong support for the University of Nairobi's Integrated Legume Research Program (beans and cowpeas) was mentioned by Dr. Majisu as part of the overall plan to be carried out in conducting the semi-arid crop improvement program.

Because of a technicality that required Kenya government approval 30 days before a visit for in-country travel the team was unable to visit the Dutch AID bean research team working with the Ministry of Agriculture at the Thika Horticultural Research Station or other government institutions relative to the CRSP trip such as the Plant Quarantine Station at Muguga. Although not usually a problem, the USAID Mission official (who had had no previous information that a team would be visiting) would not tolerate visits to the research stations, even though the University of Nairobi would have provided transportation for such visits. However, we were fortunate enough to be able to meet Dr. B.H. Waite, Director of the Plant Quarantine Station of the Kenya Agricultural Research Institute at Muguga while he attended some meetings held at ILRAD. He mentioned a serious need for technical training for Kenyans as one of the main problems, particularly training those at a level who would be able to conduct the functions of the Quarantine Station when he leaves. Dr. Waite had been at the Station for only 3 months, and the position had been vacant for 10 months at that time, and his concern with training centered on this aspect.

Although the team was unable to visit the research stations, etc., it is believed that sufficient contacts were made to effectively evaluate the potential CRSP areas where supplementary or complementary assistance and support would be helpful. In summary these are:

- 1) with the University of Nairobi in its established bean and cowpea programs;

2) the USAID Mission has elaborate program plans for research and training to fit projects planned for the semi-arid areas in East Kenya and could not at this time outline specific areas where the CRSP can effectively interface;

3) the Government of Kenya, in assessing their needs for support and cooperation with the USAID Mission and UNDEP (FAO) semi-arid regional projects, is not prepared at this time to indicate how the CRSP could supplement their programs. Training of technical personnel was mentioned, but training would begin at a later time when they are able to evaluate more clearly the needs in the legume production projects.

## **B. Tanzania**

### **1. USAID Mission**

**Visited: Peter Shirk, Deputy Director**

Our visit with USAID personnel was considerably shortened because of the Memorial Day holiday on Monday, May 28. We met with Peter Shirk on the morning of the 29th as a result of previous telephone arrangements and discussed briefly with him the CRSP and our objectives for the visit. He was interested but did not know how the CRSP might fit in with their present program, which is centered on grain production. The meeting was shortened because of a staff meeting of their group and because we had made previous arrangements to hire a car and visit with the University of Dar es Salaam Agricultural College located at Morogoro, which is 126 miles from Dar es Salaam.

Mr. Shirk mentioned to us the IITA program at Ilonga Research Station (40 miles beyond Morogoro) but our shortened schedule did not permit a visit there. However, Dr. Patel, Plant Breeder at the Ilonga Station, was in Dar es Salaam and he visited with us concerning their program.

### **2. University of Dar es Salaam, Faculty of Agriculture, Morogoro**

**Visited:**

**P. R. Kavisha, Assistant Dean of Students**

**Dr. B. J. Ndunguru, Plant Physiologist**

**Dr. A. L. Doto, Plant Breeder**

**Dr. M. J. Chowdhury, Soil Microbiologist**

**Mr. A. Naq, Food Science and Technology Department**

The College is located about 126 miles from Dar es Salaam, and the road there is blacktopped and in fair shape. Following telephone contact with the Dean of Faculty, Prof. M. L. Kymo, a luncheon meeting was arranged with key faculty working on beans and cowpeas. Unfortunately Dean Kymo had meetings outside the College and could not join us, but he was represented by Mr. P. R. Kavishe, Assiat. Dean of Students.

The discussion of the bean/cowpea program was led by Dr. B. J. Ndungura (bean program), who was assisted by Dr. M.S. Chowdhury, Soil Scientist, and Dr. Doto (cowpea program). The approach to the research program for both beans and cowpeas is an interdisciplinary type designed to integrate plant science, soil science and plant protection (disease and insect) into the program.

The Ministry of Agriculture is engaged in the improvement of legumes, with emphasis on beans (Phaseolus vulgaris) and the cowpea (Vigna unguiculata). Beans are grown in the relatively wetter area of the highlands, with cowpeas grown in the highlands and in the lower, drier regions. The bean program (breeding and variety trials) has been underway for 3 years, while the cowpea program (variety testing) has been underway for one year. Dr. Doto, who recently completed his Ph.D. at Nottingham, is heading this program.

Although seed bean production of bush type cultivars for European export has been a major industry in northern Tanzania for generations, little to nothing has been done with the cultivars used by the subsistence farmer. The Tanzanian Ministry of Agriculture has recognized this need and is emphasizing the need for increased research on all food legumes. Bean research at the Morogoro Station is just in the initial exploratory phases. They have grown some local varieties obtained from several outside sources (total plus or minus 1500) to evaluate them for agronomic characteristics, diseases and insect pests. Dr. B. J. Ndungura, Plant Physiologist, is initiating a study of bean plant characteristics in a number of locations to evaluate the genotype environmental interactions, and Dr. Chowdhury, Soil Microbiologist, will isolate and evaluate N<sub>2</sub> fixing capability of rhizobium collections. Dr. Karel, Entomologist, is scoring the type and severity of insect damage to Dr. Ndungura's plots, while Dr. Keswani, Plant Pathologist, is scoring the type and severity of the diseases found. We did not visit with Drs. Karel or Keswani, but discussions with Dr. P. N. Patel, Legume Breeder/Pathologist, IITA/USAID/Tanzanian Grain Legume

Research Project at the nearby Llonga Agricultural Research Institute, indicate they have about the same disease and insect problems encountered in Kenya. The type and severity of the problems would vary somewhat with season and environment. Their Plant Breeder, Dr. A. L. Doto, would like to study some of the genotype environmental interactions. The information generated by this team evaluation should provide valuable germplasm for a potentially productive breeding program.

A visit was made to the variety plot studies at the Research Station. IITA is cooperating in providing seed lines in cowpeas, and has a staff of six people located at Llonga Research Station about 40 mi. beyond Morogoro. This group is working on various production problems on beans and cowpeas, and is cooperating to a limited extent with the Morogoro program.

The total program on beans and cowpeas at Morogoro appears to be well planned and is sufficiently staffed with well trained scientists (10 of 12 faculty in the Crop Science Department with titles of lecturer, session lecturer and professor have Ph.D.s) to carry out a good research program on grain legumes, and they are sufficiently supported with plot space and agricultural operations.

The critical constraints are:

1) laboratory equipment and supplies (chemical and basic) for making routine measurements and special equipment for research on basic problems for that area;

2) technical backup support is seriously needed. At present funds are not available to support technicians, and the faculty is required to do the entire research program, thus seriously limiting a research program;

3) transportation to the Llonga Field Station or to the College Research Station is extremely limited, and therefore collection of data when needed from the field studies is a critical problem in the research program.

4) short term assignment of U.S. scientists, particularly in the plant protection areas, is needed and would be welcomed by the faculty;

5) long term assignments would also fit into the program; living accommodations could be provided;

6) training of technicians to support the staff is available from the diploma program (about 100 undergraduates at the College); although the need for Ph.D.s in the bean/cowpea program is not critical, a provision should be made for this aspect during the expected 5-year program.

### 3. Llonga Research Station

Because Monday, May 28, was a USAID holiday, our time for programming in Tanzania was limited to one day. We were not able to visit with the Ministry of Agriculture, but were assured by Peter Shirk, Deputy Director at USAID, that the Bean/Cowpea CRSP is fully supported by the Government of Tanzania (GOT). We had hoped also to visit the Llonga Research Station, but one day did not allow time for that visit. A large project on legumes is being conducted at the Station, "IITA/USAID Tanzania Grain Legume Research Project," a National Legume Research Program for Tanzania (cowpeas, green gram, phaseolus bean and soybean). However, we were fortunate to meet Dr. P.N. Patel, Legume Breeder/Pathologist of IITA, at the hotel. He has been at Llonga since 1975, and he discussed with us the general program, and in particular his cowpea breeding program for resistance to pest and disease. He believes that during this period of time he has identified the important pests and diseases in Tanzania relative to legume production, and the following summarizes his work on cowpeas and the relevance to disease and pest control in Tanzania:

1. Diseases of grain legumes in Tanzania: distribution and relative importance.
2. Breeding of cowpeas for multiple disease resistance and high yields in Tanzania.
3. Strains of cowpea yellow mosaic virus in Tanzania and sources of resistance.
4. Genetics of host reaction in cowpea to strains of cowpea yellow mosaic virus in Tanzania.
5. Studies on the prevalence of sap transmissible viruses in cowpea in Tanzania using differentially reacting cowpea cultivars.
6. Reaction of elite cowpea cultivars to some diseases in Tanzania during 1978 under both natural epiphytotic and artificial inoculations.
7. Sources and inheritance of resistance in cowpea to the strain of cowpea aphid borne mosaic virus prevalent in Tanzania.
8. Pathogenic variability and host resistance to bacterial pustule pathogen in cowpea.

9. Inheritance of resistant reactions to race 1 and 2 of bacterial pustule pathogen in cowpea.
10. Inheritance of resistance in cowpea to bacterial blight disease.
11. Host resistance to important diseases of green gram (mungbean) in Tanzania.
12. Reaction of bean germplasm lines to important diseases in Tanzania.
13. Bacterial pustule disease of soybean in Tanzania: Reaction of some AVREC breeding lines.
14. Pathogenic variability in bean halo blight organism in Tanzania.
15. Cowpea selection and breeding work in Tanzania during 1976-1979.
16. Green gram cultivar evaluation in Tanzania during 1976-1979.

### C. Malawi

#### 1. USAID Mission, Lilongwe

visited: Gil Scheinbaum, American Embassy staff  
Mary Quinn, Program Coordinator

The USAID program is just getting underway as they have not had a program in Malawi for several years and were concentrating their efforts in Swaziland. Mr. Cole, assigned as the Agricultural Officer, was in Washington, D.C. Mr. Scheinbaum, assigned to the Embassy and formerly in charge of the Agricultural section, discussed briefly with us the Malawi Department of Agricultural Research (DAR) and indicated the cooperative nature of the proposed program. A rough draft of the program proposal to assist the DAR was made available to us for a quick review during our visit. In brief, the project was concerned with grain crops (maize, sorghum, etc.), farming systems dealing with all crops, and studies on production economics. The approach would be an integrated research project, but the total program was not developed.

The level of skills of the DAR is low and is an acute problem, research equipment and physical facilities are inadequate or nonexistent, even for routine plant and soil analyses. At present the total complement of technical officers and assistants is 348; the project plan is to upgrade and increase the number to 411. However, housing must be provided at the research stations

before recruitment for the project and training can be initiated. At present there is a need for systems or activities directed toward assisting the small farm holders.

At this point in time, with programs yet to be initiated or adequately defined, the role of the Bean/Cowpea CRSP in a supporting role cannot be defined.

2. University of Malawi, College of Agriculture at Bunda

Visited:

Dr. O. T. Edje, Plant Physiologist

Dr. L. K. Mughogho, Irrigation Specialist

M. L. Mwinjilo, Agriculture Engineer

Dr. Y. P. Rao, Plant Pathologist

Dr. W. A. B. Msuka, Plant Pathologist

Arrangements to visit the College of Agriculture were arranged directly by phone with Dr. O. T. Edje of the Crop Production Department. The program, an integrated approach involving several disciplines, is primarily concerned with beans. Cooperation in this phase has been established with CIAT and IITA, where a few varieties of cowpeas are being tested in field plots. The following is a summary of the visit and indicates where support is needed in their program:

The Bunda College of Agriculture campus at Lilongwe is relatively new (plus or minus 10 years), the staff relatively young, and well trained for teaching and research. Many are currently abroad in the U.S. and England working on advanced degrees. Dr. O. T. Edje, Plant Physiologist, is in charge of the bean program and, with the cooperation of Irrigation Specialist Dr. L.K. Mughogho, and Plant Pathologists Drs. Y. P. Rao and W. A.B. Msuka, he has evaluated a large (2,000) collection of Malawi varieties and lines from CIAT and all over the world. The best of these determinate and indeterminate types have been used in a series of well-conducted cultural-agronomic experiments in mono and mixed (maize) culture to investigate such factors as spacing, fertilization, time of planting, mixed cropping, planting patterns, strip cropping, relay cropping, polycropping bean blends and staking. They have also studied the relative effects of various degrees of defoliation (bean leaves are sometimes used as a green vegetable) and the effects of the number of pods per

per plant on dry seed yields. Their rhizobium inoculation results show a slight but insignificant advantage to inoculation. Since most of their beans are relatively poor N<sub>2</sub> fixers, they get responses to artificial N up to 60 kgs/ha; phosphorous also is needed to up to 30 kgs/ha. Disease control sprays at fortnightly intervals can almost double yields, indicating the relative importance of halo blight, rust and anthracnose. A mild mosaic virus symptom resembling bean common mosaic virus was found in a visit to their field plots, although Dr. Edje was unaware BCMV was in the country. Producing seed under dry season conditions using furrow irrigation reduces disease incidence and severity immensely. However, most small farmers do not have access to irrigation during the dry season. Sometimes there is enough residual soil moisture in some areas toward the end of the long rainy season to allow small white canning beans (Mexico 142) to mature in the dryer but cooler environment (June-July-August) with fewer disease problems. However, low soil temperatures during emergence are a problem during this period, and Dr. Edje is screening for cvs able to emerge rapidly and uniformly under these conditions. White canning type beans are grown only for export; Malawians prefer reddish colored (i.e. Canadian Wonder and Dark Red kidney types) because the cooked bean resembles a piece of meat. Dr. Edje and his colleagues would welcome any Title XII collaboration at the primary level. One of their greatest needs is a Plant Breeder to develop locally adapted multiple disease resistant cvs of the regionally preferred types.

#### D. Botswana

##### 1. USAID Mission

Visited: Jack Morris, Agricultural Development Officer

Contact by phone was made with Phil Bueschler, USAID Representative-Research, at his home on Sunday, June 3, 1979 and he had received the telex sent from Tanzania indicating our arrival. Arrangements were made to visit with Jack Morris on Monday, June 4. He had contacted LeRoy Peters, Chief of Crop Improvement Division of the Government of Botswana, but support is paid by USAID and they had asked him to be responsible for our visit to Botswana.

USAID is seeking continuing funding for a project (FY 1981) to increase the capability of the GOB/MOA to develop and expand crop research activities for commodities grown by small farmers. The frequent droughts and difficult ecological conditions of Botswana require special efforts to gain research information needed in small farmer programs. Dryland crop research has been underway since the 1960's, largely supported by Great Britain. AID involvement has been marginal and limited to crop screening (corn, millet and sorghum). It has become apparent that genetics/plant breeding, soil fertility and cash crops have not received effective attention, largely due to limited numbers of qualified researchers. The GOB is now planning a major new Arable Lands (ALDEP) program with emphasis on small farmers, and needs an accelerated fully-developed research program, along with improved research and extension linkages. The program is designed for a geneticist/plant breeder, cash crop (legumes/pulses/oil seed) specialist, soil fertility specialist and research liaison specialist. They would join the staff of the Arable Lands Research Station and carry out their specialized activities with other team members under the direction of the Chief Research Officer. Counterparts would be identified and sent out of country for appropriate training.

The major outputs projected for the four year program are:

- a) Data on specie and variety adaptability of plants to be grown by small farmers.
- b) Improved field trials program.
- c) Closer linkages between research and extension personnel.
- d) Trained Botswana research personnel.

The proposed AID-financed inputs for 1981 are:

- 1) Contact with Title XII institutions.
- 2) Procurement of research equipment/commodities.
- 3) Initiation of counterpart training.

The life of project cost is estimated at \$2,800,000.

## 2. College of Agriculture

Visited: Dr. Duane Everett, Professor of Education, SDSU  
Dr. Dale Reeves, Plant Breeder, SDSU

The College of Agriculture serves agriculture and animal health programs. A 5-year Title XII project has recently been awarded to South Dakota State University (SDSU) to upgrade the curriculum, assist in restructuring the certificate program, to develop and implement a diploma program, and to upgrade the staff to handle the new programs. About 15 staff will be trained in the U.S., 15-20 at the Swaziland University, and the certificate program will be increased from 125 to 250. New buildings to accommodate these changes are planned.

Botswana and Swaziland have had a common share in the University located in Swaziland but are now separated to some degree, which gives impetus to developing a full program in agriculture and the animal health sciences in Gaborone, Botswana. Dr. Duane Everett, who is accompanied on a long term assignment by Dr. Dale Reeves, briefed the team on SDSU's project.

### 3. Ministry of Agriculture, Department of Agricultural Research

Visited: Dr. LeRoy Peters, Chief, Crop Improvement Division, COB  
D. E. Gollifer, Chief Arable Crops Research Officer  
K. Oland, Director of Research

The Ministry of Agriculture Research Station is located adjacent to the College just outside Gaborone but is operated independently under government policy. The research unit has two research officers in entomology, a crop screening specialist, a soil fertility specialist, and a plant nutritionist. They are supported by a staff of five technical officers, 12 technical assistants, and 4 laboratory assistants. Several of the technical staff have received further training at the international centers (IITA, ICRISAT, CIMMYT) and other places that fit their specialities.

The role of the Division of Arable Crops Research is to develop information to increase and stabilize crop production. Emphasis on production of legumes was initiated in 1976, and nutrition studies of these crops were initiated in the 1977/78 crop year. Cowpea variety "Black Eye" trials (the preferred type in Botswana) were started in 1947. In accord with the new legume research plan, special emphasis was placed on cowpeas in 1976 when germplasm was obtained from IITA.

The priorities in the new ALDEP legume program are: 1) groundnuts, 2) cowpea, 3) sunflower, 4) white haricot beans, 4) soybeans. Some trials will be carried out with chickpea, tepary bean, jujube bean, pigeon pea and china pea. Although the emphasis on this report is on cowpea, about 13% of the arable land (650,000 ha in crop farming) is listed under beans and cowpeas but is not separated as Phaseolus vulgaris or Vigna unguiculata. The climate of Botswana is generally semi-arid, and overall is better suited to cowpea production. However, some observation trials on Phaseolus vulgaris were initiated at Sebelle in 1977-78; these were obtained from CIAT and Cambridge, U.K. and will be further tested at Sebelle and Mahalapye Research Stations.

In discussing the Bean/Cowpea CRSP program in terms of ongoing research and future research plans, the following needs for their research program to overcome the constraints are:

1) Technical backup support in the cowpea research program. An example of this is the research being conducted by Ms. G. Maphanyane, B. Sc. Agric., University of Swaziland, who began screening cowpea varieties for nutrition studies in 1977/78. Technical support for this program for the field work and laboratory work is sorely needed in view of the emphasis on legumes and the need for nutrition information. Other areas in the proposed research plan for improving and stabilizing legume production would be greatly strengthened with technical support.

2) Long term support by U.S. scientists, such as plant pathologists, agronomists, soil scientists (interested in soil physical properties), or plant scientists on weed control would greatly increase the research output towards meeting the research objectives.

3) Short term U.S. scientists. This group could assist in program research planning, conducting experiments, identifying plant and pest diseases, and suggesting controls.

4) Training of technical support will probably be met by the College of Agriculture and its upgrading program. There is a need to train some students to the Ph.D. level to broaden the areas of research in plant pathology, soil science and in soil and water management. This aspect should be coordinated with USAID training programs in their crop production projects.

5) The GOB has expressed a strong interest in cowpea collaboration. Their renewed interest in grain legume production, both as a cash crop and from a nutrition standpoint, as well as small farmer assistance, is a positive step in seeking collaboration. Housing is very limited in Gaborone and providing space for long term support may be a problem. They have indicated their support in this effort as needed and to the best of their ability in cooperative programs. (See attached material prepared by Mr. Collifer in support of their interest).

#### 4. Botswana Agricultural Marketing Board (BAMB)

Visited: Peter Mulligan, Executive Director

Executive Director Mulligan outlined the functions of the BAMB in price setting, supply and distribution, and stabilization of prices. A system of storage depots has been provided throughout the country (8 of 11 are now in operation and all will be by September 1979). This plan appears to be a viable system for marketing throughout Botswana, and additional increases in yield production through the research plans should not cause marketing problems.

### E. Zaire

#### 1. USAID Mission

Visited: James E. Hawes, Food & Agric. Officer  
Walter Boehme Program Officer

Mr. Hawes had received our telex sent from Dar es Salaam and had programmed our visit. The USAID program, with a strong emphasis on grain legumes, was recently submitted to AID/W for funding and a contract was signed with Multiple Agribusiness Systems Inc. (MASI) in Washington, D.C. The 4-year project will be located at Mulungu Research Station in eastern Zaire, 25 miles from Bukava. The project objectives are:

- a) to increase the capability of the Institut National pour l'Etude de la Recherche Agronomique (INERA);
- b) create productivity packages for food legume production (beans, cowpeas, soybeans, etc.) through adaptive and applied research at Mulungu Research Station;

- c) provide reliable production potentials and limitations of soil in Zaire; and
- d) allocate INREA's resources for optimal use.

The Mulunga Station has 1000 ha and is located at about 2000 m altitude. Most of the land is cultivated with relatively deep silty loam soils that are well drained. The long term staff for the project are: soil scientist, land classifier, research agronomist, rural sociologist, management planner, laboratory technician, and business management consultant. There are 12 short term backup staff for disease and insect control, extension, soil fertility, etc. Cooperation in variety testing will be with PNM/CYMMYT, IITA, Intsoy and local screening. Training will include counterparts and advanced training M.Sc. degrees in the U.S. from selected counterparts, and short courses for INERA staff. The total program will operate under the auspices of INERA in cooperation with USAID. Transportation to the outlying area at Mulunga Station from Kinshasa is extremely difficult and will be handled by use of a small aircraft from Kinshasa.

## 2. Government of Zaire

Visited: Citizen Mukendi Mbuyi Tshingowa, Secretary of State for Agriculture (equivalent to a Vice Minister)

Citizen Mukendi discussed the role of INERA and their very strong interest in grain legume production. At present they have agreements with CYMMYT on maize production and with IITA on cassava; no contact has been made with CIAT on beans.

We discussed in general terms work being done at other Research Stations at Yangambi, Gandajika, M'Vuazi as well as Mulunga. Special mention was made that living accommodations and family facilities are available at M'Vuazi where research is being conducted on common pea, peanuts and cowpeas, among other crops. This Research Station is located between the coast and Kinshasa and IITA's cassava program is located at that Station.

Citizen Mukendi has a very strong interest in grain legume production because of the short supply of food that apparently exists at the present time

in Zaire, and also because a large part of the diet is cassava, and nutrition studies have shown the need for protein that could be supplied by the legume food crops.

There are a number of constraints relating to a bean/cowpea CRSP in Zaire:

1) The French language. MASI is having problems with this aspect in filling their program staff, even though the backup universities for the project are the University of Illinois and Hawaii;

2) a supporting role for any bean/cowpea project by a U.S. university or other institution would be with INERA and may not offer a strong institutional link for research, but might offer such links for certain training aspects;

3) affiliation with INERA could be made at certain Research Stations, but more information would need to be obtained on this point by an interested U.S. institution;

4) there is a possibility of affiliation with the MASI program, but this would come under INERA. Also, the field studies will not get underway until the second year because of the logistics involved in getting equipment, housing etc., completed before the program gets underway.

At the present time the economy in Zaire is extremely inflated, increasing at the rate of 100-200% in the last 2 years, and it does not appear to be decreasing. Director Gamble (IITA) indicated a default in payments to their cassava program, and because of this they have decreased their staff support considerably. How this inflation trend will affect a collaboration program cannot be determined, but there exists a negative attitude among some U.S. universities for programming in Zaire.

#### **F. IITA, Ibadan, Nigeria**

##### **Visited:**

Dr. W.K. Gamble, Director General  
 Dr. B.N. Okigbo, Deputy Director General  
 Dr. P.R. Goldsworthy, Leader, Grain Legume Improvement Program  
 Dr. W.H. Reeves, Training Officer  
 Dr. R. Lal, Soil Physicist  
 Dr. L. Jakai, Entomologist (postdoctoral)

Since IITA was officially visited by Dr. D.H. Wallace and the Bean/Cowpea CRSP team representing West Africa the comments here will be brief.

Director Gamble discussed the training available at IITA. He expressed the need for American graduate students to fill the void of talented backup support for the permanent staff. He indicated that with the large legume improvement program (including cowpea) and the need to continue the farming systems studies to incorporate legumes into the rotations, many openings for talented American graduate students could be made available through Title XII at IITA that would include: agronomy, entomology, physiology, pathology, plant breeding, microbiology, virology, soil science, nematology and farming systems. This would provide an applied approach to subtropical research more relevant to the African situation than is now available at American universities.

Dr. Reeves, Training Officer, mentioned that at present 35 graduate students are at IITA, but nearly all are from developing countries or Europe. Title XII could offer an opportunity to train American graduate students, and this, on their return as U.S. university staff, increases the institution's technical base for overseas assignments.

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## SUMMARY - EAST AFRICA

W. Mwangi

### Faculty of Agriculture, University of Dar-es-Salaam, Morogoro, Tanzania

The department of Agricultural Economics at this facility is relatively young. The Acting Chairman is Prof. Foote (MSU, 1935) since the Chairman (a Tanzanian) is in the U.S. undertaking a Ph.D. program. There are a few other expatriates in the department. No socio-economic study is being undertaken or has been undertaken in the area of beans and cowpeas and the future capability by Tanzanians in the department to undertake such studies will take a few years to build.

The Ibinga Research Station has been provided with a farming systems economist by IITA, a Dr. Jodha, formerly with ICRISAT. Any collaboration with this station would lead to such studies as socio-economic factors influencing the production of beans and cowpeas in Tanzania.

While at Morogoro we also visited with Dr. A. Haq, Department of Food Science and Technology, the department that deals with studies on nutrition impact of various crops. Here again the department is young and there is no Tanzanian with a doctorate. Thus, it is mainly concentrating on training of Tanzanians to take over. The main research work has been on MSci theses, two of which have been written on the nutritive value of cowpeas and beans as seeds; these studies have shown that the protein content of these seeds is greater than 15%. A MSci thesis is being completed on the protein content of cowpea leaves.

The major constraint here is finance. The availability of funds would lead to accelerated training of local faculty as well as easing such constraints as transport, lack of laboratory equipment and space. It was felt that there is a spirit of cooperation, but again local capability will take time to build. Consequently, what research can be undertaken on nutrition impact of beans and cowpeas will be limited to MSci theses for a while unless CRSP brings in personnel.

### Malawi - Bunda College of Agriculture

Here the department of Agricultural Economics as such is nonexistent. A lot of work has been done on breeding of beans by Dr. Edje et al., but nothing has been done on the socio-economic side and the capability to undertake such studies is lacking; only one Malawian Ph.D. Agricultural Economist has returned from the U.S. to undertake his thesis research. Thus, any cooperation with the College in the area of socio-economic studies would mean that CRSP would have to provide not only the funds but the personnel to undertake such studies. Hence, their first basic need is to train local personnel. The work on nutrition is also lacking since the College does not have a department of Food Science and Technology. This would mean that the first need in the area of nutrition would be to establish such a department from scratch.

### Botswana

The USAID in Botswana mainly cooperates with the Ministry of Agriculture since the Faculty of Agriculture is located in Lesotho. The Ministry of Agriculture has a Research Station which has been doing some work on cowpeas and beans; the area of socio-economics in production of these legumes has been ignored. The current program submitted to AID by the Ministry of Agriculture for funding of the Research Station includes such professionals as plant breeder, soil scientist, agronomist, etc., but no farming systems economist. It would appear that planners are only interested in natural scientists at the Station; the role of a farming systems economist needs to be included. The planning section of the Ministry of Agriculture is including socio-economic studies on various food crops, and perhaps the results of these studies will enlighten the policy makers concerning the role of agricultural economists in the whole area of food production. The CRSP, if involved, should at least provide the Research Station with a farming systems economist as the local capability in this area is lacking and there is no work being done on nutrition.

### Zaire

In Zaire as in Botswana USAID cooperates with the Ministry of Agriculture.

The little work that is being done on beans and cowpeas does not include any work on socio-economics of the production of these crops. The local capability is lacking and any involvement of CRSP would mean provision of both finance and personnel in this area. In the area of nutrition USAID is undertaking a consumption survey in Western Zaire to attempt to determine nutrition problems in the area.

In trying to rejuvenate the M'Vuazi Research Station the USAID program completely ignores the role of farming systems economist. This is unfortunate, as again if CRSP were to be involved it would mean providing such capability.

## SUMMARY - EAST AFRICA - BEANS 8

M. J. Siibernagel

Beans are grown extensively in Kenya, Uganda and Tanzania. It is the most important pulse crop in Kenya (being grown on virtually every small farm), with about 322,600 ha, most of which is intercropped with maize (1 and 2). Uganda produces beans on about 300,000 ha, and Tanzania on about 12,000 ha. They are best grown at altitudes between 1,000-2,000 m, and require about 300-375 mm of rainfall over a 10 week-2 month period, followed by a 4 week dry period for harvest. Varieties are usually mixtures, but Canadian Wonder, Rose Coco and Miwezi Moja are favorites in Kenya and Tanzania. Mexico 142, a small white dry bean, is grown mainly for canning and export. French beans are also grown mainly for export or consumption by expatriots.

In Uganda, Banja 2 and Mutibhe 4 are the leading varieties. Seed yields average about 500 kg/ha, but have a potential of 2,000-3,000 kg/ha if all recommended production practices are followed. For the subsistence farmer however, pesticides and fertilizers are out of the question for a low priority crop like beans. Primary emphasis is placed on cash crops, which are taken care of by men, who also collect and handle the cash returns. Often the proceeds go into purchasing beer, and the family is forced to sell food beans and seed stocks for next year's crop in order to buy necessities.

The "shamba" or family garden is mainly taken care of by women, who sell part of the excess produce to pay children's school fees. The potential return from the best cash crops (coffee, tea, sugar cane, sunflower, pyrethrum, etc.) often causes reduction in planting of food crops like maize and beans, which then have to be purchased later for food and seed.

Later, if the family then cannot afford to buy a nutritionally balanced diet, malnutrition ensues (as much as 80% in children under 5). In most cases high carbohydrate weaning foods such as cassava, maize gruel and banana mush are heavily used. Protein-rich foods such as beans/cowpeas are seldom used

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for weaning because of digestibility (diarrhea) problems. This may be partly due to insufficient cooking in areas where cooking fuel is scarce. A May 29, 1979 article in the Tanzania Daily News cites a government official as requesting the Tanzania Food and Nutrition Center to advise the government on cheap ways of preparing weaning foods.

A possible future source of collaboration in the nutrition field will be the traditional Nutrition Research Institute, which is under the Government of Kenya Ministry of Health, and which will be directed by Dr. Steven Kinaote, who is presently at Cornell University working on a MSci degree on international nutrition under an AID scholarship.

The consumption of beans in the average Kenya diet was estimated by Dr. Mukunya to be 1/4-1/2 kg/day, mixed with other foods such as maize, potatoes and other vegetables. Beans have increased in price as much as eight-fold in the past few years, making them less available in the diets of poor people to whom they are a primary source of dietary protein.

Dr. I.M. Gomez, with the University of Nairobi Department of Food Science, is presently very interested in collaborative nutritional studies with legumes, and is part of an Integrated Grain Legume Project which also includes agronomy, weed science, soil chemistry, plant pathology, microbiology, entomology, and plant breeding. This group has a Rockefeller Foundation grant to study pest management techniques for small scale mixed cropping farms. The project is called the Plant Protection Program (PPP) and is just finishing its first year. This program allows for some exchange scientists and some graduate student training.

The four major areas under study are: 1) entomology, 2) plant disease (fungal and bacterial), 3) virology-nematology, and 4) cropping systems and weeds. The work will progress in three phases: 1) a field survey, 2) an evaluation of cropping systems, and 3) experimentation on pest management practices. The main objective of the PPP is to train students and encourage research in systems of integrated pest management, with special emphasis on the problems of small farmers since more than 75% of the small farmers in East African countries have 3-5 acres of land.

A meeting was held with available members of the PPP team at the University of Nairobi, Kabete (agricultural) campus. In general the group is young, well trained, and eager for collaborative Title XII bean/cowpea research at the primary level in the following areas:

Dr. D.M. Mukunya and Dr. J.P. Singh - Fungal and bacterial diseases of beans in mixed cropping systems, halo blight, and anthracnose are the primary diseases, although common blight, angular leaf spot and bean common mosaic virus (BCMV) are also frequently encountered. Diseases and pests are the principal causes of yield reductions. Beans are not planted late in the season (whereby they could take advantage of the dry harvest conditions) because late-planted beans are more subject to aphid damage and aphid-vectored BCMV. Most farmers don't recognize disease as abnormalities because they see them so frequently.

Dr. E.M. Gathuru - Plant Virologist - Viral diseases of beans in mixed cropping systems. Bean common mosaic virus (BCMV) is widespread but usually of low frequency because of early planting when aphid populations are low. No work has been done to identify which strains of BCMV are present in any parts of Africa. However, the cool, wet conditions during the early part of the rainy season are most conducive to the rapid, severe development of rust, halo blight and anthracnose. All these diseases are seed-borne, so farmers perpetuate their own problems. If BCMV could be controlled, growing beans in the dryer part of the season could greatly reduce damage from rust, halo blight and anthracnose. "Bean yellow spot" is also seed-borne, widespread and low in frequency. It may be of potential economic importance however, in regard to future bean seed production programs for genetically improved varieties.

Dr. S.O. Osiru - Crop Physiologist - Cropping systems used by small farmers. The most common mixture is maize and beans, with maize being the most frequently grown and most important crop. Beans were also found in mixture with potatoes, mostly in the short rains period, while maize and beans were most frequent during the long rains.

Dr. D.N. Ngugi - Crop Physiologist/Weed Scientist - Cropping systems and weeds on small scale farms. Maize and bean mixtures were found<sup>to</sup> have about 30 species of weeds in 13 families. Hand-hoeing with available family labor is the main means of weed control. Herbicides or tractor cultivation is only feasible for high return cash crops like coffee or tea. A few practice some rotation to reduce weeds, pests and disease and to maintain soil fertility. The shortage and/or expense of hand labor and the low return on beans precludes more than early season control to give the maize and beans a head start. By harvest, weeds are thick. Improved, low cost methods must be developed that are compatible with mixed cropping.

Prof. C.P.M. Khamala, Dr. M. Mueke, Dr. S. Karel - Entomologists - Insect pests of beans in mixed cropping systems. The most damaging insect pests found on beans were the bean fly *Ophiomyia phaseoli* and *aphis fabae*. Both of these pests can be controlled by pesticides, but these are generally too expensive and their safe use too complicated for the subsistence farmer. Biologic control (predators or parasites) or genetic resistance should be found to these and other insect pests.

Dr. S.O. Keya - Microbiologist - Role of rhizobium  $N_2$  fixation in beans in mixed culture. There is a need to isolate and evaluate strains adapted to their highly weathered, acid soils. Beans are often found without nodulation. Once superior adapted strains of rhizobium are found, commercially available inoculum needs to be produced locally. There is a need to develop suitable carriers using endogenous materials, and for student training for advanced degrees abroad.

Dr. Seali - Soil Scientist - Mentioned some highly acid soils (pH 3.5-5) require liming, and that aluminum toxicity can be a serious problem in sensitive crops like beans. Genetic tolerance to aluminum toxicity would be desirable.

Dr. R.S. Pathak - Plant Breeder - Is making selections among locally adapted cowpea mixtures for seed types, leafy types (for fresh vegetable use), and combination types. The Bean Breeding is presently being done by a Dutch AID

group at the Ministry of Agricultural Horticultural Research Station at Thika. We were unable to visit this group, but their tour is almost completed and they will soon be returning to Holland. A number of Kenyan graduate students need to be trained in breeding for disease resistance so the Kenyans can carry on their own program of variety improvement. These students could work with the other members of the PPP (and for the Ministry of Agriculture) on their return. The main breeding emphasis is for resistance to Halo blight, rust, anthracnose and Bean Common Mosaic Virus.

Beans are available for seed increase and distribution through private (Kenya Seed Co.) and government channels (Ministry of Agriculture/Extension Service). In summary, the academic and governmental climate for potentially fruitful research and training collaboration with members of the agricultural faculty at the University of Nairobi appears extremely good.

## RESEARCH PROPOSAL

(Tanzania)

NAME: B. J. NDUNGURU

FACULTY AND DEPARTMENT: Faculty of Agriculture, Forestry & Veterinary Science  
University of Dar es Salaam, Morogoro, Tanzania

SUBJECT OF PROPOSED RESEARCH: Phaseolus Research in Tanzania

### OBJECTIVES:

The status of research on *Phaseolus vulgaris* (beans) is critically inadequate at present in Tanzania, although it is one of the most important grain legume groups in the country. The Ministry of agriculture is engaged in the improvement of grain legumes in general, but much emphasis has been laid on cowpeas, and to certain on other grain legumes. *Phaseolus* beans are grown in the relatively wetter highlands (of cowpeas) either as a sole crop or in mixture (Acland, 1971), most production occurring on small holdings where there is little use of mechanization, fertilizer, chemical weed control and pesticides. Commercial production is only being carried out in the northern part of the country.

Several factors limit bean production, including, among others, plant diseases and pests. Grain yields of *Phaseolus* beans vary considerably but they commonly range between 60 to 750 kg/ha, although experimental yields close to 3000 kg/ha are common in trials carried out at CIAT (Cummings, 1976). These low yields are associated also with the use of varieties which have low yield potential. Within the species, tremendous variations exist in size, shape, colour, texture and taste and there seems to exist tremendous potential for improvement of both yield and quality (TAC, 1975). In recognition of the place of beans in the human diet, the Bean Improvement programme is to be initiated with the objective of essentially finding and assembling an efficient and economic package for dry seed production.

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What Has Been Discovered About This Problem and What Remains to be Done

In grain legumes present evidence suggests that a common set of components is essential for all high yielding ideotypes (TAC, 1975) namely

- a. high pod number potential
- b. greater number of seeds per pod
- c. large seed size (weight)
- d. a canopy profile structured for maximum light interception
- e. node number, internodal lengths, and branching pattern in keeping with the requirements of (a-d) above
- f. leaf size and orientation in keeping with items (a-c) above, and with the cultural-environmental situation
- g. a growing period and leaf area duration to fit the needs of the cropping system in use, but which should be as long as possible in the reproductive period
- h. a root and stem morphology (physiology) capable of undering the crop effective symbiosis (Sinha, 1977)
- i. structural attributes favouring a high partition ratio of total plant dry weight increases into grain

On the basis of the existing information about grain legumes and the environments in which the crop is to be grown, superior lines might be exploited for breeding purposes.

Work Proposed to be Done, Where Work to be Done, What Method to be Adopted

Initially work will involve assembling and evaluating the germplasm to determine the relative yield potential of plants with different growth habits and to evaluate their responses to intra-crop competition. Response to inoculation by *Brizobium*, by which the nitrogen fixing ability of beans can be maximized will also be studied, together with the distribution of fixed nitrogen to different parts of the plant. Studies will also be conducted on plant structure and physiology in order to seek traits that will bring higher yields.

**Probable Duration of the Work**

3 years initially

**Importance of the Results to be Obtained and Where You Hope to Publish Them**

The ultimate goal is increased bean production, the importance of which has been stated in the preceding section. Results will be published in any relevant Agricultural Research Journal.

**Names and Addresses of Persons to be Consulted Concerning this Application**

Dr. R.J. Summerfield, University of Reading  
Plant Environment Laboratory, Cutbush Lane  
Shinfield Grange, Shinfield, Reading, England

Prof. E.H. Roberts  
Department of Agriculture and Horticulture  
University of Reading, Earley Gate, Reading, England

**Bodies to Which Application Has or Will be Made for Assistance in the Project**

None

# Cowpeas, a crop for dry conditions

(Botswana)

## INTRODUCTION

Botswana is situated between latitudes  $17\frac{1}{2}^{\circ}\text{S}$  and  $27^{\circ}\text{S}$  and has a land surface of 562,000 Km<sup>2</sup>. It consists of an elevated plain of between 1200 and 1400 m above sea level. Approximately 85 per cent of the country is covered by Kalahari sand, on which grows a low thorn bush savannah vegetation. The climate is semi-arid, the average yearly rainfall varies from 700 mm in the north east to less than 250 mm in the south west. The rain falls in the summer months (October-April). Rainfall in the main arable areas varies from 550 to 350 mm per annum, but the variation in annual rainfall is high. Mean maximum temperatures rise to 33°C (January) and mean minimum fall to 4°C (June/July) at Gaborone. During the summer months the soils have high surface temperatures (up to 70°C) and evaporation rates are high. Pike(1) estimated that the potential evaporation of freely watered crops was 1400 mm per annum, with daily maximum of 13.6. The total open - water evaporation (ten year mean) at Gaborone is 1731 mm per annum.

Due to climatic factors, Pike(1) estimated that arable dryland agriculture can only be practised without extreme risk in an area of approximately 45,000 km<sup>2</sup> of suitable soils in the south-eastern region of the country. Probably only between 2-3% of the total land area is suitable for dryland agriculture if areas of poor and shallow soils are taken into account, and even in that small area the risk of crop failure is still high.

As a result of the semi-arid climate, Botswana is principally a pastoral country, but the distribution of cattle is such that nearly 50% of farmers have insufficient cattle to make a living from them. Dryland farming is the most wide-spread economic activity in Botswana and a 1971 Agricultural survey showed that of 69,000 rural families, 87% had farming lands of whom 52,000 (75%) planted in an average year. Of these families half were able to plough using their own draught power and the other half had to rely on assistance with draught animals from other farmers. Only 9% of farmers ploughed with a tractor. Other factors limiting crop production in Botswana besides drought and draught power are extremes in temperature, pests, diseases, birds, weeds (including witchweed) and an inherent low soil fertility.

Government policy is to increase arable crop production by introducing more profitable and reliable methods of farming and to ensure that every rural household has the opportunity to obtain a useful income from agricultural activities. This is to be done by encouraging production of cash crops, marketing of surplus food grains and the development of new farming activities.

#### RESEARCH PROGRAMME

Agricultural research does contribute to the implementation of Government policy by providing information and indicating ways in which the aims of the Botswana Development Plan can be achieved. Part of the research programme of work is to screen germplasm of cowpeas Vigna unguiculata so that the varieties and types best suited to the environment can be selected. Cowpeas have been selected as a crop which should be given emphasis in the research programme, because they are an important high value food crop, and are well adapted to the environment and are capable of producing reasonable yields of grain even in dry years. This is probably due to the fact that the roots can extend deep into the hard soil (Fig. 1) whereas the roots of sorghum, maize and sunflower are inhibited in these dense soils. Cowpeas are therefore likely to be a useful crop in rotations as the deep penetrating roots are capable of improving the physical conditions of the soil and the soil chemical status may be enhanced by nitrogen fixation.

Selection criteria for screening cowpea germplasm will be tolerance to drought conditions, earliness of maturity, a determinate flowering habit, an upright growth form and high yields of good sized quality grain. Resistance to diseases including cowpea mosaic virus (CPMV) and to infestation by insects in the field and in storage will be sought. After the improved cowpea types have been selected for Botswana conditions, agronomic and harvesting practices will be investigated. There will include studies on fertilizer use, weeding, time of planting, spacing, intercropping and investigations into suitable harvesting and threshing techniques. Initial studies on the role of cowpeas in rotation have been initiated because of their beneficial effect on soil chemical and physical properties.

PREVIOUS RESEARCH

Germplasm evaluation

Variety trials in Botswana have been carried out since at least as far as back as 1947. Table 1 shows the yields obtained during several seasons for the cultivar 'Black Eye' (2,3,4,5,6,7,&8).

Table 1. Seed yields in (Kg/ha) for the cowpea variety 'Black Eye'

Season	Seed Yield(Kg/Ha)	Site
1950/51	161	Mahalapye (Lat. 23° 8'S, Long. 26° 50'E)
1951/52	678	Mahalapye
1953/54	1,110	Mahalapye
1954/55	691	Mahalapye
1962/63	967	Gaborone (Lat. 24° 34'S, Long. 25° 57'E)
1966/67	598	Mahalapye
1967/78	812	Goodhope (Lat. 25° 28'S, Long. 25° 27'E)
1970/71	1624	Sebele
1971/72	1,121	Sebele
1972/73	475	Sebele
1976/77	1,180	Mahalapye
1977/78	463	Sebele

With effect from the 1976/77 season, germplasm was introduced from the International Institute for Tropical Agriculture in Nigeria (IITA). The highest yields obtained from this material were 2031 Kg/ha (1976/77) and 1730 Kg/ha (1977/78), (7&8). During the dry season of 1979/80, yields of up to 800 kg/ha were obtained at Sebele where total precipitation for the period 1 July/28 February was 346 mm. Planting took place during late October.

Farmers appear to prefer the Blackeye type of cowpea because of its large seed size and flavour. The disadvantages of the variety Blackeye are (1) indeterminate flowering habit i.e. flowering over a long period of time which requires several harvests and hence more labour, (2) semi-upright growth habit, often long, trailing runners that make harvesting more difficult, (3) low - yielding ability and (4) susceptibility to parasitisation by witchweed *Alouatta malina*. (4)

On farmers land the highest recorded yield of 'Blackeye' cowpeas obtained during the 1977/78 season by the Evaluation of Farming System & Agricultural Implements Project was 780 Kg/ha (9).

### Spacing

The few trials conducted on spacing of cowpeas have failed to achieve a significant difference between treatments. Espacements tested were inter and intra row spacings of 60 & 90 cm and 15 & 30 cm, respectively (2).

### Rotations

In a four - course rotation experiment comprising cowpeas, cotton, maize and sorghum which was maintained for eight years the detrimental effect of growing the same crop continuously was apparent for all crops. The advantage of a rotation was to double the yield of the four crops rotated compared to those grown continuously on the same site (4 & 5).

A four course rotation on the ox-unit (10 and 11) comprising sorghum, millet, cowpeas and sunflower produced yields of Blackeye cowpea of 849, 100, 713 and 1135 Kg/ha in four successive years. Yields of the variety 'Rhenoster' in a rotation of sorghum, cowpea maize and sunflower during this period were 800 kg/ha (10 & 11).

### Tillage

A tillage trial incorporating a rotation of sorghum, cowpea, maize and sunflower was conducted at Sebele (10 & 11) which compared the use of the mouldboard plough (200 mm depth); chisel plough(200 mm); shallow sweep (100 mm) and precision strip tillage using a subsoil type plough (250 mm) on subsequent crop growth and yield. In the shallow sweep treatment, no significant sorghum, maize or sunflower root growth was observed below the tillage depth of 100 mm. However the cowpea roots were observed to extend to 400 mm(Fig. 2) and were therefore able to penetrate through the hard soil below the tillage depth whose bulk density was shown to be  $1.8 \text{ Mg/m}^3$  (11). Many of the soils of Eastern Botswana have high bulk densities (c.  $1.8 \text{ Mg/m}^3$ ) and the cultivation of cowpeas on these sites will improve the soil physical properties. This is particularly important in circumstances where draught power is limiting and implementation of deep tillage difficult if not impossible.

## Harvesting and threshing

The labour requirement for harvesting cowpeas is high (up to 440 men h/ha) and it was estimated that for all operations the grain yield per unit of labour input varied from 0.8 - 2.1 kg grain/man hour (10 & 11). It is for this reason that investigations into suitable harvesting and threshing techniques have been included in the research programme so that the labour inputs can be reduced. Time of planting should be taken into account so that harvesting does not coincide with the period when sustained rainfall is likely, or compete for labour during the cereal harvest.

## Intercropping

Investigations into intercropping have only just been started in Botswana. Willey (12) has outlined the useful role that cowpeas can play in intercropping system. It is increasingly apparent that this approach should be applied to crop research in Botswana, to determine if crop production can be substantially increased by the adoption of this system of cropping.

### SEED MULTIPLICATION UNIT

The Seed Multiplication Unit of the Department of Agriculture Research organises the production of seed of sorghum, maize, millet, cowpeas and sunflower for sale to farmers. Table 2 shows the distribution of cowpea seed by cultivar for the 1978/79 season.

Table 2                      Distribution of cowpea Seed by the  
Seed Multiplication Unit

<u>Variety</u>	<u>Amount (metric tons)</u>
Black Eye <sup>1</sup>	15.6
Tswana <sup>2</sup>	9.7
Rhenoster <sup>3</sup>	2.4

1. Semi upright habit, indeterminate flowering, good quality seed, susceptible to parasitization by Alectra.
2. Fairly resistant to parasitization by Alectra. Medium sized seed. Yields well in dry years, but in wet years produces vines at expenses of seeds.
3. Upright habit, determinate flowering, small brown seed, fairly resistant to parasitization by Alectra. Not favoured by consumers.

### ABSTRACT

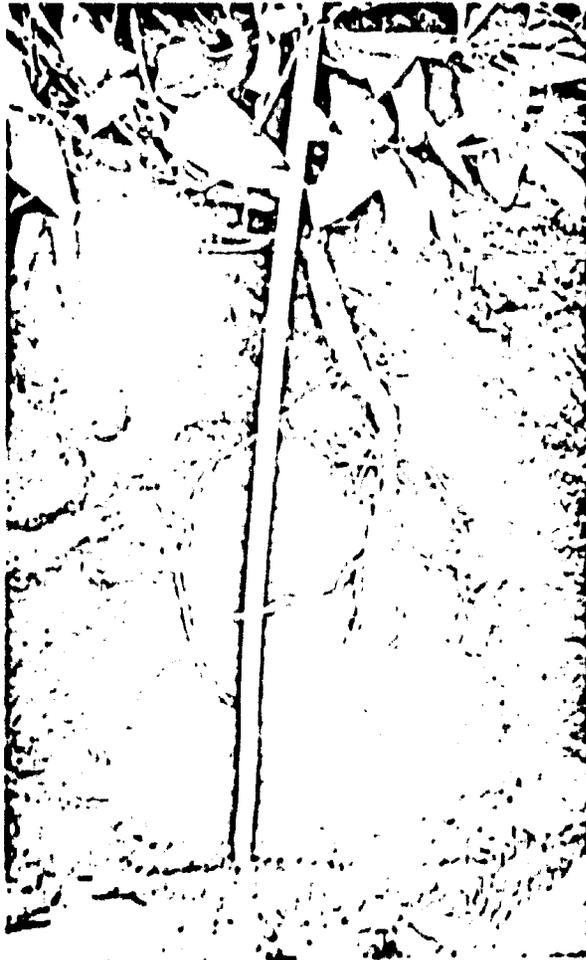
Cowpeas yield well, even in dry years in the arable areas of Botswana where the normal precipitation is 400-500 mm. The roots penetrate deep into the soil, under conditions in which the roots of sorghum and maize are unable to penetrate. Cowpeas would be a valuable component in a crop rotation system, as the deep penetrating roots may create a favourable soil condition for the production of good subsequent cereal yields.

### ACKNOWLEDGEMENTS

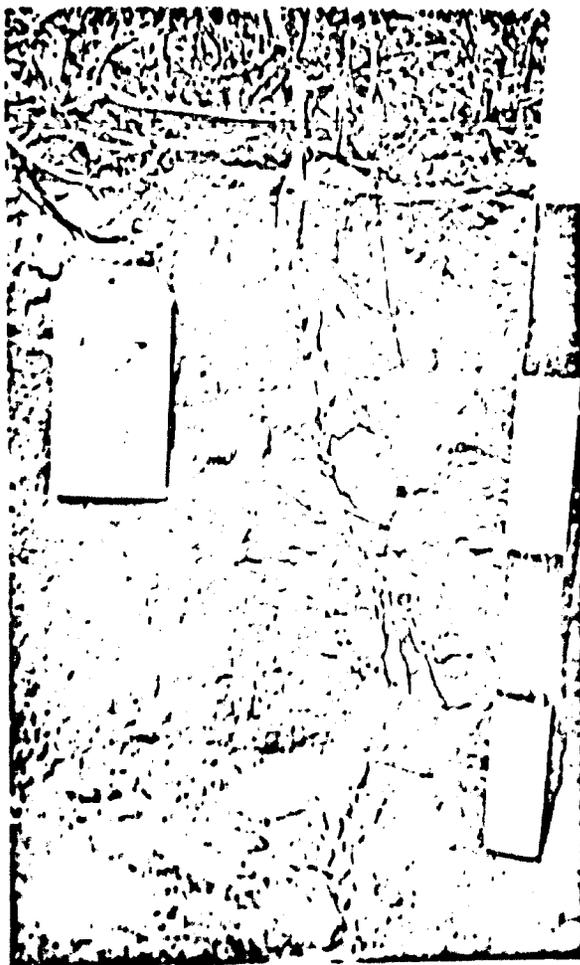
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**Fig. 1. Cowpea roots extending deep into the soil profile during the dry season of 1976-79 at Sabele.**



**Fig. 2.** Cowpea roots growing to a depth of 400 mm are able to penetrate through the plow (cultivation) pan which developed in the shallow 100 mm tillage plots (1977-78) at Sabela.