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1983 ANNUAL REPORT

TECHNICAL SUMMARY

THE BEAN/COWPEA COLLABORATIVE
RESEARCH SUPPORT PROGRAM
(CRSP)

MICHIGAN STATE UNIVERSITY

Funded through USAID/BIFAD Grant No. AID/DSAN-XII-G-0261

The complete 1983 Technical Summary is available in Spanish. The reports of those projects underway in Brazil are available in Portuguese and those in Senegal and Cameroon are available in French. These special language editions are available from the MO.

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COVER PHOTOS:

Center -- Rust on cowpea leaves.
Bottom -- Bruchid on stored bean.
Top -- Beans cooking at home site.
Right -- Harvested cowpeas in pods.

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INTRODUCTION

The Bean/Cowpea CRSP is a program of coordinated projects in Africa and Latin America addressing hunger and malnutrition through research on the production and utilization of beans (Phaseolus vulgaris) and cowpeas (Vigna unguiculata). The goal of the Bean/Cowpea CRSP reflects the mission of the Title XII "Famine Prevention and Freedom from Hunger Act" of the US Foreign Assistance Act under which the program is funded. It is to establish active and vigorous collaborative research efforts that will contribute to the alleviation of hunger and malnutrition in developing countries by improving the availability and utilization of these foods. In the true spirit of collaboration, the CRSP also makes a significant contribution to agriculture in the US through the increased knowledge and materials generated by the research partnerships with Host Countries (HCs). The research findings and identified biological resources hold potential for solving or reducing important agricultural constraints to bean and cowpea production in the US and other legume producing nations.

Beans and cowpeas are dietary staples in the HCs associated with this CRSP. Among many families, these legumes provide the major source of high quality, affordable protein as well as an important source of B vitamins. Beans and cowpeas generally are grown as food for household consumption, rather than as export crops. They are typically grown on subsistence farms and, in some countries, are grown solely by women, on whose shoulders rests the major responsibility for providing the food for family consumption. CRSP research seeks to strengthen the resources available to these producers.

To support its goal, the CRSP directs its attention to:

1. Building strong and collegial professional relationships among the HC and US leadership in each project;

2. Making financial resources available for both HC and US research activity;

3. Emphasizing multidisciplinary research integrating production and non-production issues;

4. Focusing on research in traditional settings;

5. Paying specific attention to the roles and participation of women;

6. Being alert to mechanisms for information dissemination; and

7. Supporting HC educational opportunities to strengthen long-term legume research capability within the country.

CRSP research is concerned with genetics and plant breeding, agronomics, economics, nutrition and socio-cultural factors. A global research plan, developed jointly by HC and US colleagues, formed the basis for the design of the eighteen collaborative projects.

These vigorous international research partnerships directly involve research institutions in thirteen HCs, two international centers and fourteen US agricultural research institutions, which include the nine having lead roles in the CRSP. Funded in September of 1980, the Bean/Cowpea CRSP has now been in existence for three years.

Bean/Cowpea CRSP Strategy

The Bean/Cowpea CRSP strategy is to bring together the scientific resources of the identified countries to address universal constraints to the production, availability and consumption of beans and cowpeas and to address the constraints through research in settings where they have unique local importance.

Toward this end the program supports research which encompasses the following objectives:

1. Variety improvement;

2. Insect and disease control;

3. Productive and stable farming systems management with special attention to beans and cowpeas;

4. Efficient nitrogen fixation and soil phosphorus utilization;

5. Drought and heat tolerance;

6. Improved seed and seed availability;

7. Improved storage and methods of preparation;

8. Improved nutrition and digestibility;

9. Reduced cooking requirements; and

10. Understanding of the socio-economic implications of agronomic intervention.

While individual projects are directed toward specific production/consumption constraints, a number of generalized goals are shared by all the projects. These include:

1. Training HC professional and technical personnel;

2. Strengthening research capability in collaborating institutions;

3. Building long-term collaborative relationships among senior US researchers, their counterparts in research institutions in HCs and HC/US professionals-in-training; and

4. Recognizing the social and environmental constraints to small farmer production and the central role that women play in agriculture in many HC contexts.

The CRSP avoids unnecessary duplication in existing research. It participates with national programs and regional and international centers in identifying constraints and in planning and executing research. It will utilize the same linkages to disseminate its research findings.

General Features of CRSPs

The Bean/Cowpea CRSP is one of seven current CRSP programs. Unique features of CRSPs include:

1. The involvement of leading scientists from US institutions, many of whom would not otherwise be engaged in international work;

2. Major resource contributions from US and HC institutions which combine to nearly equal the United States Agency for International Development (USAID) contributions;

3. Scientist-to-scientist and institution-to-institution linkages with major emphasis on program activities in HCs; and

4. Dual benefits to both US and HC agriculture which offer an incentive to state legislatures and universities to participate.

Unique Features of the Bean/Cowpea CRSP

While the Bean/Cowpea CRSP shares common features with other CRSPs, it has organizational and administrative characteristics which give it a separate identity. These characteristics are listed below.

1. A manageable yet large enough number (nine) of Title XII lead institutions provide a rich pool of professional leadership and ecological diversity for CRSP research: Colorado State University (CSU), Cornell University, Michigan State University (MSU), University of California (UC), University of Georgia (UG), University of Nebraska (UNE), University of Puerto Rico (UPR), University of Wisconsin (UW) and Washington State University (WSU).

2. Research teams with broad technical expertise from lead institution scientists are often augmented by researchers from other collaborating US institutions. One project includes five collaborating US institutions, one includes three and five include two collaborating US institutions. The remaining ten projects involve a single US institution. In addition, Boyce Thompson Institute for Plant Research manages one project.

3. Collaborative relationships exist with institutions and/or universities in thirteen countries in East and West Africa, Central and South America and the Caribbean: Botswana, Brazil, Cameroon, Dominican Republic, Ecuador, Guatemala, Honduras, Kenya, Malawi, Mexico, Nigeria, Senegal and Tanzania. Brazil hosts three projects; the Dominican Republic, Guatemala and Nigeria each hosts two projects; and the remaining countries host one project.

4. In the planning process, the entire array of projects, US and HC institutions and investigators were identified prior to the operational

establishment of the CRSP. Thus, the collaborative partnerships were in place at the initiation of each project.

5. There is a Women-in-Development (WID) position on the CRSP Management Office staff. With a program management role, the WID specialist is well integrated into the on-going functioning of the Management Office. Through various media, she facilitates the attention of the projects to WID-related issues and the participation of women as appropriate.

6. A policy of expending a minimum of one-half of project funds in or directly on behalf of the project's HC is maintained. These funds include money for HC nationals studying in the US and equipment purchased in the US to be transported to the HC.

ORGANIZATION OF THE BEAN/COWPEA CRSP

Michigan State University was awarded the Bean/Cowpea CRSP grant and became the Management Entity (ME) in September, 1980. The University created a Management Office (MO) for CRSP activities. Three groups--a Board of Directors (BOD), a Technical Committee (TC) and an External Review Panel (ERP)--work closely with the University and MO to guide the CRSP through policy decisions, budget allocations, research strategy, review and evaluation. In addition, the CRSP enjoys critical support both from an AID program officer, B. L. Pollack, and a liaison to the Board for International Food and Agricultural Development (BIFAD), William F. Johnson.

The Board of Directors

The BOD is the executive committee for CRSP policy and budget. It consists of five institutional representatives (IRs) from the US lead institutions elected for two-year terms. IRs are designated by the chief executives of their institutions to represent them in CRSP policy and administrative matters. They are typically administrators of international programs, deans or experiment station directors. The BOD elects a Chairperson and Secretary.

The members of the BOD for FY (Fiscal Year) 83 were:

Dr. Donal Johnson (Chair)
Dean, College of Agricultural Sciences
Colorado State University

Dr. Landis L. Boyd (Secretary)
Director, Agricultural Research Center
Washington State University, Pullman

Dr. Antonio Vélez Ramos
Associate Dean and Deputy Director
Agriculture Experiment Station
University of Puerto Rico
(Replaced May, 1983 by Ing. Miguel González-Román)

Ing. Miguel González-Román
Associate Dean and Sub-Director
of Agriculture Experiment Station
University of Puerto Rico

Dr. Calvin Qualset
Associate Dean, College of Agriculture
and Environmental Sciences
University of California, Davis

Dr. Dale Harpstead
Chair, Department of Crop and Soil
Sciences
Michigan State University

The BOD held three meetings during the year. Action taken at those meetings included:

1. Review of the ERP report and enactment of policy decisions as appropriate in response to the ERP findings;

2. Institutional backing in project conflict resolution in the US;

3. Guidance and support in the organization of the MO; and

4. Collaboration with the TC in the development of a budget policy concerning US/HC distribution of funds. Major issues addressed were as follows:

   a. The existing policy indicated that not less than 50% of USAID funds for support of projects be spent in or directly on behalf of HCs. This was adopted (1) in order to insure CRSP focus on the solution of HC problems rather than on the maintenance of existing research programs of US institutions and (2) to nourish a climate of collaboration and partnership between the US and HC Principal Investigators (PIs).

      The TC supported this policy and recommended that it be based on each total grant period. This recommendation was passed by the BOD.

   b. Experience to date has demonstrated that the US PI is uniquely restricted when institutional indirect costs for project support are taken solely from the US 50% of the total funds. Therefore, the TC recommended that the 50/50 split be applied to the total project budget exclusive of all indirect costs. This recommendation was passed by the BOD.

   c. It was noted that some projects have not settled into a spending pattern in the HC comparable to that in the US. Thus, in order to maintain the approved distribution of project funds, more of each year's funds would have to be allotted to the half of the team spending less. Assuming that authorized project spending suggests the progress of approved research activity, it is appropriate to encourage HC utilization of project funds. Therefore, the TC recommended that where HC spending patterns are seriously below the expected level, the HC and US PIs be requested to submit to the MO for TC discussion the rationale for the spending patterns and their suggestions for addressing the issue, including possible recognition of an unrealistic HC budget level. The BOD approved this recommendation.

5. The BOD gave review and approval of project and MO budgets for FY 84.

6. The BOD gave review and approval of the Memoranda of Understanding (MOU) between the CRSP and each of the two international centers, Centro Internacional de Agricultura Tropical (CIAT) and International Institute of Tropical Agriculture (IITA).

The Technical Committee

The TC advises the BOD, ME and MO in areas of research technology, project management and technical research strategy. It has specific responsibility for technical monitoring of the eighteen CRSP projects, review/revision of the CRSP Global Plan, establishment of priorities for new research, evaluation of new proposals, development of criteria for evaluation of existing projects and development of plans for TC meetings abroad. The TC consists of five investigators engaged in CRSP projects from US institutions plus two international members--one from an international research center and one from a participating HC institution. TC members are appointed to two-year terms by the BOD.

The members of the TC for FY 83 were:

Dr. Fred Bliss (Chair)
Department of Horticulture
University of Wisconsin, Madison

Dr. Ricardo Bressani
Chief, Division of Agriculture and Food Science
INCAP, Guatemala City
Guatemala

Dr. Dermot P. Coyne
Department of Horticulture
University of Nebraska, Lincoln

Dr. Julio López-Rosa
Office of the Dean
College of Agricultural Sciences
University of Puerto Rico, Mayagüez

Dr. A. E. Hall (Secretary)
Department of Botany and Plant Science
University of California, Riverside

Dr. Matt Silbernagel
USDA/SEA/AR
Irrigated Agricultural Research and Extension Center
Washington State University, Prosser

Dr. Shiv R. Singh
Assistant Director and Group Leader
Grain Legume Improvements Program
IITA, Ibadan, Nigeria

The TC held five meetings during the year. Actions taken included:

1. Endorsement of CRSP-wide annual technical workshops designed primarily for HC students studying in the US to expose them to technology beyond their own disciplines. One such workshop on Biological Nitrogen Fixation (BNF) sponsored by the Brazil/UW (Bliss) project was held in 1983. Another on the Micro Computer Statistical and Data Management Package (MSTAT), a computer software package for a broad range of agricultural research, is scheduled for 1984 under the auspices of the Mexico-Malawi/MSU projects.

2. Cooperation with the MO in a CRSP-wide Contracts and Grants Officers meeting to review CRSP operating procedures and develop common understanding of issues and methods.

3. Review and follow-up of the ERP recommendations with appropriate project actions taken, especially relative to identified troubled projects.

4. Development of a format and procedure for CRSP communications including annual reports; the newsletter, Pulse Beat; and technical publications such as Advances in Grain Legume Sciences.

5. Development of communications to support CRSP technical materials, i.e., log frames, baseline data plans.

6. Cooperation with the Director of the Grain Legume Program at IITA in planning the World-Wide Cowpea Conference to be held fall, 1984.

7. Review and support of the MOU between the CRSP and each of the two international centers, CIAT and IITA.

8. Discussion with project leaders of the appropriateness of changes or additions in project objectives and strategies as these were proposed to the group.

The External Review Panel

The ERP is advisory to USAID-BIFAD, the ME and the CRSP as a whole. It is responsible for review and evaluation of CRSP management and the progress of project research activities. The panel members, nominated by the BOD and approved by the Joint Research Committee (now Joint Committee for Agricultural Research and Development) of BIFAD, are:

Dr. Clarence C. Gray, III (Chair)
Professor, International Extension and International Studies
Virginia Polytechnic Institute and State University

Dr. Peter E. Hildebrand
Food and Resource Economics Department
University of Florida

Dr. Melvin Blase
Agricultural Economics Department
University of Missouri

Dr. Antonio M. Pinchinat
Tropical Agricultural Research and Development Specialist
IICA, Lima, Peru

Dr. A. Hugh Bunting
Agricultural Development Overseas
University of Reading, England

Dr. Charlotte E. Roderuck
Director, World Food Institute
Iowa State University

Dr. Luis H. Camacho
INTSOY Plant Breeder
CIAT, Cali, Colombia

The 1983 review focused on evaluation of the research and management of the projects at the HC sites. After the extensive review, the ERP members reported that in their travels they found this CRSP a productive new initiative of a kind different from traditional foreign assistance. They felt that this model contributes considerably to international agricultural development and to improvement of the US image abroad. A separate 1983 ERP report is available from the MO.

The Management Office

The MO is charged with facilitating activities of the CRSP on behalf of the ME, providing staff resources to the BOD, the TC and the ERP and facilitating the progress of the individual projects. The MO consists of a Director, a half-time Deputy Director, a WID/Program Specialist and an Administrative Officer plus office support staff.

Ms. Nancy Axinn resigned as WID Specialist in January, 1983 and moved to Nepal. In June, 1983 the Director, Dr. Donald Isleib, resigned his position to become Associate Dean and Director of the Institute of International Agriculture at MSU. Deputy Director Barnes-McConnell was then named Acting Director. Thus, at the end of FY 83 the MO staff, augmented by the brief three-month return of Ms. Nancy Axinn to help out in a period of staff transition, included:

Dr. P. W. Barnes-McConnell, Acting Director
Deputy Director (vacant)
Ms. Anne Ferguson, WID Specialist/Program Specialist
(appointed September 26, 1983)
Mr. George A. Davies, Administrative Officer
Ms. Darlene Romsos, Office Assistant
Ms. Irma Gutierrez, Secretary/Receptionist

Subsequently both Ms. Romsos and Mr. Davies terminated their employment with the MO during the fall of 1983.

Activities undertaken by the MO included:

1. Project progress was monitored; the ERP, TC and BOD recommendations were followed-up; and project activity was supported. Representatives from the MO visited the following HCs: Brazil, the Dominican Republic, Guatemala, Honduras and Malawi.

2. The MO organized and staffed the 1982 ERP Annual Review in November, 1982 at MSU with all project teams represented, including some HC PIs.

3. Materials were prepared and staffing was supplied for three BOD meetings and five TC meetings. Facilities for the meetings and in some cases travel support were also arranged by the MO.

4. The MO maintained communications through phone, telex and letters with the projects as was needed. Travel clearances, equipment requests and contract clarification were routine requests. In addition, the MO attempted to support the needs of projects in the field which were experiencing communications difficulties or problems regarding official AID procedures.

5. The WID Specialist focused on increasing the awareness of the scientists to women's roles as cultivators, processors and consumers of beans and cowpeas. News items and publications to strengthen the WID component of the CRSP were shared with the scientists. Many research teams reflected this awareness by increasing their efforts to include women as trainees and as collaborating scientists. Several HC teams included women scientists. Additionally, CRSP male scientists increasingly expressed a sensitivity to WID issues in developing their research plans and in data analyses. In

their 1983 review, the ERP acknowledged the success of these efforts demonstrated in an improved attitude of HC and US male professionals toward working with professional women and in increased efforts to advance women through the system.

6. For administrative purposes, numerous domestic trips to US lead institutions and Washington, DC were taken throughout the year.

7. The MO maintained an ongoing interaction with the Management Offices of the other CRSPs and with USAID and BIFAD staff members concerned with CRSPs. This included a presentation by the Bean/Cowpea CRSP and other CRSPs to USAID and BIFAD in Washington, DC.

8. Presentations by MO staff were given at various national meetings. Major addresses were given by the WID Specialist (Ms. Axinn) at the National Association of State Universities and Land Grant Colleges (NASULGC) Annual Meeting and by the then Deputy Director Dr. Barnes-McConnell at the 1983 Annual Meeting of the Association of United States University Directors of International Agricultural Programs (AUSUDIAP). There were various other presentations given by MO staff.

9. Publications from the MO included the Annual Report (Executive Summary and Technical Summary) and two issues of the newsletter. In addition, (1) a WID Manual entitled Working with International Development Projects: A Guide for Women-in-Development was published in conjunction with the MSU Office of Women in International Development and (2) Lodwick, Axinn and Barnes-McConnell published a chapter entitled "Communications in International Interdisciplinary Research Management" in Russell, M. G. (editor), Enabling Interdisciplinary Research: Perspectives from Agriculture, Forestry and Home Economics, University of Minnesota Agricultural Experiment Station.

10. Numerous HC visitors were received by the MO, many of whom were travelling on other than CRSP funds but who felt a visit to the MO desirable and appropriate.

PROJECT ANNUAL REPORTS: FY 83

Introduction

These reports focus on the substance of the research completed during FY 83. While delays in providing approval for equipment essential to research activities continue to slow progress in some projects, exciting research data have been reported. A number of the scientists presented findings at professional meetings during the year and CRSP-related research articles are beginning to appear in professional journals.

Review of the PIs' annual reports reveals that in the HCs and in the US, in addition to the planned project collaboration, there is increasing interaction with other concerned scientists, many of whom are not formally connected with the CRSP. This is culminating in a greater focus on beans and cowpeas than was originally envisioned. A cross-national network of research

practitioners is developing which will strengthen the scientific field of bean and cowpea-related research in the US and throughout the developing world.

Women scientists are involved in many of the Bean/Cowpea CRSP research projects. In the US they are PIs of two projects and co-investigators in five projects. The involvement of women technicians and graduate assistants in project research is increasing. In the HCs, a few women scientists have been involved as members of the research teams. In Brazil, women scientists have been identified and will be used as consultants. Additionally, a significant number have been included in CRSP training programs held in that country. Women have been nominated to come to the US for training in several of the projects. In Malawi, women from Bunda College continue to participate in the field survey work. Most of the women scientists from the US spent extended periods of time this year conducting field work at HC sites.

Training of HC scientists is an important component of each CRSP research project. Candidates for advanced graduate or specific short-term training programs have been identified. Nearly every project has students from HCs already enrolled in M.S. and Ph.D. degree programs in US institutions. Many of these individuals, together with CRSP-supported US students, participated in a special CRSP-sponsored Student Trainee Workshop on BNF held at the University of Wisconsin in July, 1983. Training sessions for researchers and technicians have also been conducted in the HCs. In addition, US scientists continue to receive training in language and socio-cultural aspects of the areas in which they are working. Short-term training in the US for HC scientists in specific scientific techniques needed for research activities is also in progress.

The organization of US/HC project research management has developed based on the unique needs of each project and the professional relationship established between US and HC PIs. Basically, three successful models have evolved to fit the needs of specific sites.

1. Senior US researchers are stationed in HCs to work with national programs. This model is especially effective where the HC has very limited research personnel and the US PI acts as a stimulus to building a critical mass. Example: Botswana.

2. Junior researchers (including post-doctorates or advanced Ph.D. students) are stationed in HCs, under close and frequent supervision of senior US PIs, to work with national programs. This model is especially successful where there is an effective HC team but less than a critical mass in the identified research area. Example: Brazil.

3. No US researchers are stationed in the HCs but active collaborative relationships are maintained. This model is especially appropriate where the HC, similar to the US, maintains a critical mass of researchers including effective senior researchers. Example: Senegal.

The Technical Summaries of project activities for FY 83 follow. The 1983 Technical Summary for all projects is available in Spanish. The reports of those projects underway in Brazil are available in Portuguese and those in Senegal and Cameroon are available in French. These special language editions are available from the MO.

Development of Integrated Cowpea Production Systems in Semiarid Botswana

I. PROJECT ROSTER

A. US Lead Institution: Colorado State University (CSU)

On-Campus Representative:	Dr. Donald R. Wood, Department of Agronomy, CSU
Administrator:	Ms. Maxine Tamlin, College of Agricultural Sciences, CSU

B. Botswana Counterpart Institution: Government of Botswana (GOB), Ministry of Agriculture (MAG)

Principal Investigator:	Dr. C. J. deMooy, Department of Agronomy, CSU (resident in Botswana)
Co-Principal Investigators:	Dr. K. Oland, Director, Department of Agricultural Research (DAR), MAG
	Mr. Chris Manthe, DAR, MAG
Technician:	Mr. Efedile Mosarwe, DAR, MAG
Consultant:	Ms. J. Siebert
Peace Corps Volunteer:	Ms. Julie Concannon

II. PROJECT OBJECTIVES

A. General--The general project objective is to identify and remove constraints to cowpea production which result in traditional low yields. Project objectives are designed keeping in mind that:

1. To be applicable to farmers' conditions, improvements must be conceived at the grass roots level.
2. Recommended practices must be made specific for moisture and other environmental conditions.
3. Proposed solutions must so completely suit the farmer that he will be hard put not to accept the improvements. Although not always specifically mentioned, project objectives are meant to lead to solutions for several categories of farmers.
4. It is necessary to address separately the needs of farmers in different resource categories, all of whom belong under the heading of small farmers.
5. Separate solutions for farmers using tractor versus animal draft power are necessary.
6. Solutions must be found for the special problems encountered by women farmers.

B. Specific Objectives

1. Tillage/Planting Practices--Devise a set of tillage/planting practices whereby planting of cowpeas can begin immediately at the start of the rainy season.

2. Tillage and Moisture Conservation--Evaluate the merits of reduced tillage with simple tools especially for sandy, non-compacting soils.
3. Variety Testing--Initiate a continuing variety screening program involving local germ plasm as well as exotic lines.
4. Cultural Practices--Undertake field research for the improvement of cultural practices under specific sets of conditions.
5. Harvesting Techniques--Combine whole-plant harvesting techniques with a search for suitable varieties and machine threshing for greater returns on labor.
6. Alectra vogelii--Incorporate resistance to A. vogelii into cowpea varieties once the Evaluation of Farming Systems and Agricultural Implements Project (EFSAIP) finds the trait by screening of cultivars (cvs).
7. Demonstration Plots--Test research findings in farmers' fields with and without subsidized inputs.
8. Self-Evaluation--Arrange self-evaluation meetings for the purpose of soliciting suggestions and opinions from peers.

C. First Year Objectives

1. Hold discussions with personnel of all agencies involved in agricultural development.
2. Conduct tillage/planting experiments arriving at more timely planting and better stands.
3. Establish a local germ plasm collection and conduct variety tests for screening of promising lines.
4. Conduct field trials on cultural practices aiming at a wide range of improvements.
5. Provide practical training for the Botswanan technical assistant.
6. Train volunteer agency staff for field trial work.
7. Develop or acquire a stationary thresher.
8. Test the feasibility of once-over harvesting procedures combined with machine testing.
9. Select at least one Botswanan student and one US student for graduate training.
10. Hold an annual review meeting with all research agencies involved in agricultural development.
11. Plan the research program for FY 84.

III. CHANGES IN OBJECTIVES--None

IV. RESEARCH OUTPUTS

A. Available for Immediate Use

1. It was established beyond reasonable doubt by experimentation that many introduced varieties can surpass the nationally recommended variety, Blackeye, with respect to grain yield. One of these varieties is ER 7. Whereas the performance of the newly introduced exotic lines must be tested for several more years before any recommendations can be made, one variety, ER 7, has been grown in Botswana sufficiently long to know that it can

successfully withstand the environmental stress typical of the country. This variety is anticipated to provide a provisional solution to the problem of the lack of suitable cowpea varieties.

2. The "Description of Course Variety ER 7" was accepted for publication as Crops Research Bulletin No. 2, MAG. Essentially, this means that ER 7 is accepted for release.
3. The Botswana Cowpea Germ Plasm Catalog is ready for publication by the MAG. This approximately 100-page catalog will contain the information collected by the CRSP's germ plasm collection and field evaluation 1982-83. A total of 180 local cowpea lines are described, many times the number hitherto known to occur in the country.
4. A cowpea germ plasm collection was established including more than 400 local and 100 exotic lines. The seed will be kept permanently in cold storage and rejuvenated as necessary. Small amounts of seed are made available to other agencies upon request. Distributions already have been made to IITA and the Plant Introduction Station at Beltsville, MD.

B. Available for Use within 1-2 Years

1. Exotic cowpea lines introduced into Botswana last year have shown superior traits in the first planting. After one or more years of testing for insect and disease resistance and yield stability, several lines will be considered for seed multiplication and release as new varieties. These are to be varieties for a specific purpose.
2. As the country appears rich in cowpea land-races, at least one more volume of the Botswana Cowpea Germ Plasm Catalog will appear in print.
3. A set of cultural practices will be designed for a once over cultivation/planting procedure involving minimum tillage implements.

V. TRAINING OUTPUTS

A. United States

1. Degree Training--Ms. Karen Conniff commenced academic course work toward the Ph.D. degree during spring semester, 1983 at CSU. She is scheduled to arrive in Botswana in September, 1984 for dissertation research under the Bean/Cowpea CRSP program. Ms. Barbara deMooy started M.S. thesis research in September, 1982 under the Bean/Cowpea CRSP program in Botswana. She is scheduled to begin academic course work in crop breeding at MSU in the spring quarter, 1984.
2. Non-Degree Training--Two CSU students, one male and one female, attended the BNF Workshop sponsored by the Brazil/UW Bean/Cowpea Project in Madison, Wisconsin, July 18-20, 1983.

B. Botswana

1. Degree Training--Ms. Mmasera E. Manthe was accepted for an M.S. degree at CSU. Her program started in September, 1983 with thesis research at the Agricultural Research Station, Sebele.

Academic course work at CSU is scheduled to begin in June, 1984. Mr. Peter Montshiwa was accepted for an M.S. degree at CSU. Academic course work at CSU is scheduled to begin January 3, 1984. He will conduct thesis research under the Bean/Cowpea CRSP project in Botswana upon his return from the US.

2. Non-Degree Training--Mr. Efedile Mosarwe, holder of an agricultural certificate from Botswana Agricultural College and a technician with this project, participated in training with the Semiarid Food Grain Research and Development Project (SAFGRAD) Cowpea Field Program in Upper Volta for six months in 1983.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. Botswana

1. Regular contact with the research personnel at the DAR and associated support groups such as the British-funded Dry Land Farming Research Scheme and the Soil Testing Laboratory--The project has taken its proper place in the research establishment and reciprocates by attempting to supply to the system the information that can be reasonably expected of it.
2. Agricultural Field Services (AFS), an extension arm of the MAG--Mr. B. Tlale, Director, AFS, was contacted upon completion of the first field season. He was interested in cooperative work on the application of project findings in farmers' fields. Contacts with AFS further developed through the Regional Agricultural Officer (RAO) at Gaborone and the RAO and Crop Production Officer at Maun, Ngamiland. Twenty-one extension officers have expressed interest in conducting cooperative variety/thrip control trials in farmers' fields.
3. Integrated Farming Pilot Project (IFPP), a British-supported farming systems project--Initial contact with Mr. N. Hunter, Project Leader, and exchange of ideas with Mr. R. Edwards, Agronomist, have grown into a joint program of testing tillage/planting and intercropping practices, varieties and insect control in farmers' fields.
4. EFSAIP, also a British-funded farming systems project--Periodic discussions with Mr. C. Riches, Agronomist, and Mr. D. Horspool, Agricultural Engineer, have led to EFSAIP cooperation in the nationwide variety/thrip control trial program in farmers' fields and to development of a cultivator/planter implement for testing by the project.
5. Ngamiland Agricultural Development Project (NADP), a farming systems project led by Mr. R. Jones--A linkage has been established with this group in testing CRSP variety and insect control findings in the far northern regions of Botswana.
6. Agricultural Technology Improvement Project (ATIP), a US Government financed farming systems project--Limited cooperation has been established with this group. The CRSP has filled a request for information on forage varieties. Collection of cowpea baseline data by ATIP was arranged with Dr. D. Norman,

Team Leader, but no information had been collected after the first year. ATIP is the one farming systems group which has declined to cooperate with the regional on-farm testing of the cowpea variety and insect control program sponsored by the CRSP. It is understood that all available time is needed to fulfill other priorities.

7. Mahalapye Development Trust (MDT)--Mr. J. Spindler of MDT has offered to conduct small-scale seed multiplication of exotic cowpea varieties for which extremely little seed is available. MDT also is a cooperator in the regional on-farm cowpea variety and insect control trials.
8. Botswana Baptist Mission at Maun--The project cooperates with the mission by providing small samples of seed from local cowpea lines which are evaluated for the project under their environmental conditions. In return, the mission keeps the seed for distribution among garden club members and to stimulate interest in cowpea growing among local farmers.
9. IITA, Ibadan, Nigeria--Close cooperation with IITA has existed from the beginning of CRSP activities in Botswana. Dr. B. B. Singh, cowpea breeder of the Grain Legume Program (GLP) at IITA, selected eight local lines for a small breeding project at IITA in support of this project. The project tested 100 IITA cowpea lines and participated in the IITA international inoculation experiment.
10. SAFGRAD, Ouagadougou, Upper Volta--The project participated in the Regional Cowpea Adaptation Testing Program in 1982. A party of SAFGRAD scientists, including Dr. V. Aggarval, visited the project during January, 1983.

B. Linkages with US Institutions

1. CSU--The project is fiscally responsible to the CSU administration. The University also provides an on-campus administrator and an on-campus advisor for each graduate student being trained under the auspices of the project.
2. US Plant Introduction Center, Beltsville, MD--Seed from 72 local cowpea lines has been sent to Beltsville to be entered in their germ plasm collection.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States

1. Backstopping, on-campus management and administrative services are provided by CSU. The project is charged one month's salary for each of the three persons involved. CSU contributes the remainder from the indirect cost fund.
2. As the personnel roster indicates, CSU provides the Chief-of-Party as a research associate.
3. The Peace Corps assigned a volunteer to help with the project.

B. Botswana--The allocated resources are listed in the Project Paper. They included considerable financial support from USAID/Gaborone.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Need for Additional Field Technicians and Labor--The project's research capacity far exceeds the number of assigned field technicians and labor. Output could be greatly enlarged and interpretations of experimental results greatly improved with more field assistants.

B. Seed Multiplication--Seed multiplication activities at the station are sadly lacking in quality and quantity. Even small amounts of well-known released varieties are not available to researchers. The project has a need for multiplication of small amounts of many promising cowpea lines.

C. Transportation--It has been found that official vehicles are not available when needed. This may be expected to get worse following a recent one-third reduction of the DAR fleet. Assignment, or at least first priority use, of a BX vehicle would help the project.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

A. Cooperation with the EFSAIP agricultural engineer, Mr. D. Horspool, resulted in construction of a cultivator/planter which can be drawn by two oxen or four donkeys. Such considerable reduction of one-third draft power requirements relieves pressure on farmers. The cultivator/planter, stripped of all but two tires, becomes a once over minimum tillage implement.

B. Variety testing and the introduction of cowpea lines received great emphasis. More than 325 exotic and local lines were evaluated during the first year.

C. A beginning was made with field studies on cultural practices including date of planting, population density, soil fertility, rhizobial strains and intercropping.

D. The possibility of a new harvesting technique was explored by a combination of search for lines with certain characteristics, pulling of entire plants rather than picking pods and use of a threshing machine to replace hand threshing and winnowing. The new method proved two to five times faster than the traditional procedure.

E. Demonstration plots have been arranged in farmers' fields. Cooperative arrangements with AFS and several farming systems groups have already been made and implementation is planned during the second year of the project.

F. A Botswanan technician, Mr. Efedile Mosarwe, was sent for six months of practical training with the SAFGRAD research program in Upper Volta.

G. Ms. Julie Concannon, Peace Corps volunteer, was trained as a research assistant for the field trial program and contributed greatly to project accomplishments.

H. Two Botswanan students were selected for graduate training at CSU. One of them, Ms. Mmasera Manthe, started thesis research July 1, 1983. Two US students were selected for graduate study. One of them, Ms. Karen Conniff, started course work at CSU in January, 1983; the other, Ms. B. deMooy, completed thesis research in Botswana for an M.S. degree at MSU.

I. Annual self-evaluation meetings were held on September 6-7, 1983.

J. Planning of the field research program for FY 84 was completed.

X. BASELINE DATA

Little baseline information was collected during the year.

XI. FUTURE PLANS

Progress toward objectives was attained on all points and it appears that the objectives are accurately aimed at the needs of the cowpea farmer. The DAR is satisfied with the direction in which the project is developing. The proposed 1984 plan of work has been developed. No research is envisioned on the US campus.

Insect Pathogens in Cowpea Pest Management Systems for Developing Nations

I. PROJECT ROSTER

A. US Lead Institution: Boyce Thompson Institute (BTI), Ithaca, NY

Principal Investigator:	Dr. Donald W. Roberts, Insect Pathology Resource Center (IPRC), BTI
Co-Principal Investigator:	Dr. Richard S. Soper, U.S. Department of Agriculture (USDA), BTI
Postdoctoral Research Associate:	Dr. Stephen P. Wraight, IPRC, BTI

B. Brazil Counterpart Institution: Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)

Principal Investigator:	Dr. Almiro Blumenschein, Director, Centro Nacional de Pesquisa de Arroz e Feijão (CNPAF), EMBRAPA
Co-Principal Investigators:	Mr. Bonifacio P. Magalhães, CNPAF, EMBRAPA
	Mr. Massaru Yokoyama, CNPAF, EMBRAPA
	Mr. Belmiro Pereira das Neves, CNPAF, EMBRAPA
	Dr. Evani Ferreira, CNPAF, EMBRAPA
	Mr. João Pratagil P. de Araujo, CNPAF, EMBRAPA
US Research Associate:	Dr. Richard A. Daoust, CNPAF, EMBRAPA

II. PROJECT OBJECTIVES

A. Develop insect pathogens as pest management tools compatible (integrated) with other insect control practices. This will be attempted by conducting basic and applied research in a cowpea producing nation (Brazil) and in the US to increase the currently inadequate data base. Experienced insect pathologists will be sent to Brazil to conduct experiments with Brazilian scientists since the country currently has no insect pathologist who can be committed to cowpea pests.

B. Train developing country scientists in insect pathology so they can function independently in microbial control projects for cowpeas and other crops. In addition to the training accomplished in conducting experiments with Brazilian scientists, more formal training of scientists and aspiring scientists from developing countries in insect pathology and microbial control will be conducted.

III. CHANGES IN OBJECTIVES

None. Emphasis, however, will be changed to delete extension activities as mandated by recent instructions from AID through the Bean/Cowpea CRSP MO.

IV. RESEARCH OUTPUTS

A. Available for Immediate Use

1. The survey for insect disease agents in Brazilian cowpea and other legume pests has provided more than 100 fungal isolates to the scientific community. Some of these have been distributed to interested Brazilian, US and other scientists for possible use as insect control agents. Many fungal strains are not only identified and in pure culture (under liquid nitrogen storage) but have been evaluated in the laboratory for pathogenicity to certain insect species.
2. Methods for fungal mass production and bioassay are directly applicable to other studies of entomopathogenic fungi worldwide.
3. Development and/or refinements of insect-rearing methods have made some cowpea insect species available for non-pathology as well as insect pathology studies in Brazil.
4. Training of Brazilian scientists in insect pathology has led to requests from them for collaborative research and to their providing diseased specimens to US researchers. This apparent increased interest and knowledge regarding insect pathology in Brazil will enhance the chances of success for microbial control projects in that nation.

B. Available for Use within 1-2 Years

1. Planned surveys will provide additional insect pathogens for use by the scientific community.
2. Current epizootiology studies under field and semi-controlled conditions (screenhouses) will provide methodologies and concepts which can be applied to similar investigations worldwide.
3. Degree training of Brazilian scientists will significantly increase the expertise available in that nation in insect pathology and microbial control of insect pests.

V. TRAINING OUTPUTS

A. United States

1. Degree Training--One female.
2. Non-Degree Training--One male and two females.

B. Brazil

1. Degree Training--None.
2. Non-Degree Training--Twenty-four females and fourteen males (One woman and one man have undergone one year internships in preparation for their entry into Brazilian graduate schools.)

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. As a result of the extensive survey, collaborative research and teaching associated with activities in Brazil, significant interactions with more than 30 university and government (both state and federal) groups located in virtually all cowpea growing areas of the country have occurred. These interactions are rated as very productive and cordial and extensive exchanges of materials, ideas and personnel in future years are anticipated. The US PI, Dr. Roberts, at the Brazilian Ministry of Agriculture's request, assisted in drawing up guidelines for registration of microbials for insect control in Brazil.

B. With the encouragement of Dr. Blumenschein, the US researchers are currently trying to include other Latin American nations in the program. This will be done primarily through training. Collaborative research with CIAT in Colombia has been discussed but the special funds needed for such work have not been arranged. A short course on insect pathology and microbial control at IITA for late 1984 is in the planning stage.

C. The principal intra-Bean/Cowpea CRSP association has been with the Cameroon/University of Georgia (Chalfant) project. Both projects are concerned with cowpea insect pests and Dr. Chalfant has been particularly helpful in the area of insect rearing.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States--The administrative officers of BTI (a non-profit research organization on the Cornell University campus) have been very supportive of the project since its inception and have encouraged the enthusiastic pursuit of the project goals by the PI and other BTI staff. The bookkeeping, with its complicated divisions into HC and US and with the various levels of matching, has presented difficult problems for the BTI Business Office which have been managed with patience and dedication. Accountable financial support to the project from base BTI funds is expected to be $43,000 in FY 84. The fungal isolates collected in Brazil have been maintained by the USDA group at BTI headed by Co-PI Dr. Soper and identification of the fungal specimens was done by Dr. R. Humber of the USDA group. Although their funds are totally Federal and, therefore, not applicable as matching funds for the grant, several months' salary from USDA base funds have been expended in the support of this project.

B. Brazil--The administration of EMBRAPA, including the President, Dr. Eliseu Alves, and the CNPAF Director, Dr. Almiro Blumenschein, has been universally supportive of the collaborative project. Dr. Blumenschein has been particularly interested and helpful in insect pathology training at CNPAF and in encouraging collaborative research

projects between CNPAF scientists and the US Research Associate, Dr. Daoust, at CNPAF. As evidenced by the large number of collaborators listed in the Project Roster, extensive collaborative efforts are now underway at CNPAF. The CNPAF Business Office estimates that the financial input into the collaborative work from their base funds will be equivalent to approximately US $46,000 in FY 84.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

The principal technical problems have included the following:

A. Insect rearing has proved exceptionally difficult and time consuming. In some cases, field-collected insects have been heavily attacked by parasitic insects, plants intended to be utilized for insect food have been infected by plant viruses and spider mites have been devastating in the US to plants intended for leafhopper rearing. All solutions to these problems have proved extraordinarily labor-intensive. In addition, inadequate basic information is available on the factors needed for initiation of epizootics. This lack makes the results of field applications uncertain.

B. Some of the most interesting fungi, e.g., Hirsutella guyana, have proved difficult to mass produce.

C. The utilization of funds proved very unpredictable due to extremely difficult problems regarding importation of equipment and supplies into Brazil. Although these items are crucial, the importation licenses are very difficult to obtain even when the products are donated to EMBRAPA prior to shipping from the US. Some equipment items are available in Brazil but restrictions placed by AID on purchasing such foreign manufactured items greatly inhibit utilization of them. Also, Brazil's overall financial difficulties have had some influence on the funding available to EMBRAPA stations. Accordingly, help is no longer expected on many items previously provided, e.g., telephone, photocopying and housing allowance for Dr. Daoust.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

A. Objective--Continue development of the IPRC in Brazil including literature and microorganism repositories.
Result--Many new pathogen isolates have been added to the microorganism repository (100 isolates in total from Brazil). An information and literature repository with 2,000 scientific reprints, 15 specialized books on insect pathology or related topics and 7,000 indexed references has been established.

B. Objective--Extend surveys for pathogens of cowpea and bean pests.
Result--Five survey trips ranging from western to northern to northeastern Brazil were conducted during the second year. Some of these trips included stops in several locations.

C. Objective--Identify, characterize and improve newly discovered pathogens.
Result--A new species not successfully cultured in the first year, Hirsutella guyana, was isolated in pure culture from infected Empoasca sp. adults. Other new isolates were obtained in the genera Beauveria, Metarhizium, Paecilomyces, Nomuraea and Entomophthora.

D. Objective--Continue bioassay development and screening for promising isolates.
Result--Since they are essential for bioassay studies, insect colonies have been established for Empoasca fabae (US), Spodoptera frugiperda and Elasmopalpus lignosella. A culturing system is available for Chalcodermus aeneus and significant progress has been made in the rearing of Cerotoma sp. and Diabrotica sp. A colony of E. kraemeri will probably be established in Brazil during FY 84. Screening bioassays were extended to over 100 isolates of B. bassiana and M. anisopliae against Chalcodermus aeneus. Many promising strains have been identified and dosage-mortality studies were initiated. Extensive bioassays were also conducted at BTI against E. fabae. Several isolates have shown high virulence (up to 100% mortality). Bioassays in Brazil have also been conducted against S. frugiperda, Cerotoma sp. and Callosobruchus maculatus. At IPRC, Brazil, a new spray tower has been developed to improve the precision of bioassays.

E. Objective--Initiate small-scale production and formulation of selected pathogens.
Result--An isolate of Erynia radicans (Entomophthorales) from E. kraemeri was studied extensively. It was produced by liquid fermentation, dried, ground, preserved and formulated for field application. A small-scale production technique, adapted from Chinese technology, was developed for B. bassiana production.

F. Objective--Conduct preliminary field trials with pathogens demonstrating promise for pest control.
Result--Field trials were initiated at CNPAF on beans and cowpeas and in Piaui on cowpeas against Empoasca using the E. radicans isolates studied in D, above. Early results showed that the incidence of disease in fields was high after fungal application. Quantitative field control has still not been achieved.

G. Objective--Commence training of Brazilians or other scientists in insect pathology and microbial control by conducting short courses and by training interns and graduate students.

Result--Training of Brazilian scientists was extended. Two training courses on insect pathology were conducted and a third course is planned for FY 84. One-year post-B.S. internships have been financed by the program for one woman and one man and the interns have made plans to enter graduate training under the program. Other Brazilian graduate students are being identified. A US graduate student joined the program to study the spread of fungus diseases in Empoasca sp. populations. Field training of researchers in northeastern and northern Brazil has been started and a program of cooperation is being developed.

X. BASELINE DATA

The production of cowpeas in Brazil is extremely variable. Large producers (100 hectares or more) exist, but much smaller holdings are the norm. Virtually all cowpeas in the small holdings are grown as intercrops with up to five other plant species. The climates vary from the moist littoral and Amazons to extremely arid regions. Cowpeas are eaten as green beans in certain areas (e.g., Bahia) but the great majority are used as dried beans. Consumers of dried cowpeas show very strong regional differences as to acceptable color, size and taste and, therefore, utilize different cowpea lines. With such extremes in cropping patterns it is difficult with limited funds and expertise in the social sciences and economics to gather baseline data. Once the specific area(s) where microbial control agents may be utilized on a wide-scale basis is identified, baseline data will be gathered. An overview of topics such as where cowpeas are produced, in what amounts and which lines are preferred is available from Dr. Earl Watt of IITA, who lives in Goiânia and travels Brazil extensively in connection with the Brazilian National Cowpea Improvement Program. To date, information has been gathered from him and from our own non-specialist, informal observations made during survey trips. Should more detailed information be required, the project should be expanded to employ properly qualified specialists.

XI. FUTURE PLANS

A. Proposed Changes

1. The project objectives remain unchanged.
2. Personnel changes are possible in FY 84, but not certain. Dr. Daoust will have completed three years in Brazil at the end of FY 84, the time originally committed by him to the project.
3. Outdoor trials will be conducted primarily in screenhouses where temperature and other factors can be carefully monitored.
4. As requested by USAID, "extension" activities have been eliminated.

B. Proposed Plan of Work for FY 84.

1. Training--Training will include conducting a one-week course on insect pathology and microbial control in Brazil and completing preparations for a similar course in October, 1984 in Nigeria. Training of research interns (B.S. level) will continue in Brazil with the expectation that one or more of the interns will commence graduate training during the year. The US graduate student (Ph.D.) will commence field research on epizootiology of *Erynia radicans* in *Fabae empoasca* populations. Informal exchange of insect pathology information will continue with the Brazilian colleagues through discussions, collaborative research and visits.
2. Surveys--The search for new and/or more virulent entomopathogenic microorganisms will be continued through surveys in Brazil and, if finances and other conditions permit, in West Africa following the October cowpea meeting in Nigeria.
3. Bioassay and Insect Rearing--Laboratory studies will be expanded to encompass rearing more insect species and conducting additional bioassay tests. Epizootiological studies will include gathering baseline data on physical factors affecting the target insects and their pathogens.
4. Mycological Studies--Isolation, characterization and mass production (particularly mass production using simple technology) of fungi will be continued.
5. Outdoor Tests--Simulated field trials will be conducted with entomopathogenic fungi against insects in screenhouses.

Identification of Superior Bean-Rhizobia Combinations for Utilization in Cropping Systems Suitable to Small Farms in Brazil

I. PROJECT ROSTER

A. US Lead Institution: University of Wisconsin (UW), Madison

Principal Investigator:	Dr. Fredrick A. Bliss, Department o Horticulture, UW
Co-Principal Investigator:	Dr. Frank Dazzo, Microbiology and Public Health, MSU
Part-Time Technicians:	Ms. Debora Barnes, Microbiology and Public Health, MSU
	Mr. Charles Yokohama, Microbiology and Public Health, MSU

B. Brazil Counterpart Institution: Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)

Principal Investigator:	Mr. Pedro A. A. Pereira, Centro Nacional de Pesquisa de Arroz e Feijão (CNPAF), EMBRAPA
Co-Principal Investigator:	Mr. Ricardo Silva Araujo, CNPAF, EMBRAPA
US Research Associate:	Dr. Robert Henson, CNPAF, EMBRAPA
Field Agronomist:	Mr. Advalo Borges, CNPAF, EMBRAPA
Laboratory Technician:	Mr. Carlos A. Cavalcante, CNPAF, EMBRAPA
General Laboratory Assistant:	Mr. Aldimar F. dos Santos, CNPAF, EMBRAPA

II. PROJECT OBJECTIVES

A. Long-Range Goal--To develop superior common bean cultivars capable o enhanced BNF that, in association with superior strains of *Rhizobium phaseoli*, produce high yields under bean-only and bean-maize croppin systems without supplemental nitrogen fertilizer.

B. 1982-83 Objectives

1. Training
   a. Identify one Brazilian graduate student to begin studies in rhizobiology at MSU.
   b. Train one Brazilian graduate student (Mr. Pedro A. A. Pereira) in plant breeding and plant genetics at the M.S. and Ph.D. levels at UW.
   c. Train at least two Brazilian technical research persons in the advanced methodology of rhizobiology at MSU.
   d. Conduct a three-day summer workshop at UW on selection for BNF for graduate trainees from other Bean/Cowpea CRSP projects.

2. Plant Selection and Improvement
   a. Continue to screen Brazilian accessions and US breeding populations for enhanced BNF potential.
   b. Screen populations of inbred backcross lines developed for Brazil for enhanced N_2-fixation, high yield and good adaptation.
   c. Continue to develop new populations of inbred backcross lines suitable for Brazil.
   d. Develop methods for rapid field and greenhouse selection of lines having enhanced potential for N_2-fixation.
3. Rhizobium Collection and Evaluation--Collect and identify strains of R. phaseoli from several sources, particularly Brazilian field sites, that show competitive ability to nodulate and fix high levels of N_2 on standard bean cvs and/or superior breeding lines.
4. Factors Affecting N_2-Fixation
   a. Study the effects of major stress factors on nodulation and premature nodule senescence of standard and superior selected lines in controlled environments.
   b. Study the nodulation, fixation and nodule senescence of standard cvs and superior selected lines grown in prevailing Brazilian production systems.
5. Dissemination of Results
   a. Provide superior breeding lines to other Bean/Cowpea CRSP projects.
   b. Provide information on the methodology useful for selecting beans with enhanced potential for BNF.

III. CHANGES IN OBJECTIVES

A significant change in the 1982-83 objectives was in the area of training. There appeared to be no Brazilian student available for or needing formal M.S. or Ph.D. training in rhizobiology at MSU. This is primarily because Brazil has a long history of research and training in N_2-fixation and those needs can be met adequately from within. Consequently, the funds were used by Dr. Dazzo to hire a part-time technician to accomplish the work he needed to complete. This action was approved by the MU in June, 1983.

IV. RESEARCH OUTPUTS

A. Available for Immediate Use
   1. Breeding lines of black beans possessing potential for enhanced BNF and adapted to subtropical/tropical conditions, e.g., UW 22-34, will be entered in Brazilian regional trials.
   2. Bean breeding lines are being developed that, although not suitable for direct use as cvs, are superior parents with enhanced potential for BNF.

3. Breeding methods are being developed to facilitate the transfer of characters favoring enhanced BNF into different types of standard cvs.

B. Available for Use within 1-2 Years
1. Potential new black bean cvs
2. Additional promising breeding lines of other commercial classes of beans, e.g., Rosinha, Carioca, etc.
3. Isolates of *Rhizobium phaseoli* from different field sites in Brazil selected for superior competitive ability and BNF potential
4. Improved methods of inoculation for Brazilian farmers
5. Information about the effects of mixed cropping on BNF in bean plants

V. TRAINING OUTPUTS

A. United States
Degree Training and Non-Degree Training--None.

B. Brazil
1. Degree Training--Mr. Pedro Pereira began studies toward an M.S. degree in plant breeding and plant genetics at UW, Madison in August, 1983. He is supported by funds from Brazil through EMBRAPA.
2. Non-Degree Training--Mr. Ricardo Silva Araujo began a twelve-week course (September 15-December 15, 1983) at MSU. He will learn new techniques in rhizobiology and conduct lab experiments that are part of the research plan.

C. Other Developing Countries
1. Degree Training--Ms. Susan Nchimbi from Tanzania, who is supported by the Tanzania/Washington State University project, is beginning her second academic year of work toward an M.S. degree in plant breeding and genetics at UW.
2. Non-Degree Training--None.

D. BNF Student Trainee Workshop
Sponsored by this project, the workshop was held at UW, Madison on July 18-20, 1983. A total of 18 students took part; 4 from the US and 14 from developing countries. Of the participants, 5 were women and 13 were men. Presentations were made by Dr. Ken Shapiro, UW, Madison; Dr. Frank Dazzo, MSU; Dr. Joe Burton, Nitrogen Fixation by Tropical Agricultural Legumes (NifTAL) Research Project at the University of Hawaii; Dr. Peter Graham, University of Minnesota; Mr. Juan Carlos Rosas, UW; Ms. Dina St. Clair, UW; and the workshop's principal organizer, Dr. Fred Bliss. Workshop materials can be sent to other project personnel upon request. Contact Dr. Fred Bliss, UW.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. United States--Additional close collaboration between this project and the Mexico/MSU (Adams) project has taken place. Materials have been sent to them and their graduate student researchers participated in the BNF Student Trainee Workshop.

B. Brazil--Important linkages have developed in Brazil between this project and other Brazilian programs.
   1. There is an interchange of materials and information with the research group at EMBRAPA/Km 47 Rio de Janeiro (Dr. Dobereiner).
   2. Mr. Pereira and Dr. Henson are working with Dr. María José Zimmerman, plant breeder at CNPAF who returned recently from the UC, Riverside. She has planned breeding experiments seeking to improve BNF of Brazilian cvs and intends to make these efforts part of her on-going program.
   3. Dr. Henson is participating in Brazilian "Network" trials conducted throughout the country to identify the best *R. phaseoli* strains in combination with superior host plants.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States
   1. UW
      a. Research administration personnel to administer the grant and subgrants to MSU and EMBRAPA/CNPAF.
      b. PI, Dr. Bliss, to conduct research, direct the project and advise graduate students.
      c. Research Associate, Dr. Henson, to conduct research at CNPAF. Also labs, greenhouses and field plots for conducting the research.
   2. MSU
      a. Co-PI, Dr. Dazzo, to conduct research under the subgrant, to participate in the training of people in rhizobiology.
      b. Lab facilities for research.

B. Brazil
   1. Director of CNPAF, Dr. Blumenschein, who is responsible for administering the subgrant at CNPAF.
   2. Brazilian PI, Mr. Pedro A. A. Pereira until August 15, 1982, then replaced by Mr. Ricardo Silva Araujo, for responsibilities in directing research at CNPAF.
   3. Other technical personnel, see Section I, above.
   4. Labs, greenhouses, field facilities at CNPAF to conduct research, vehicles for limited travel.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

Only minor constraints to progress have been identified at this time:

A. No specific project vehicle is available at CNPAF to transport people and supplies to the field. This is being requested in the 1984 budget.

B. An insufficient number of technical support personnel are available at CNPAF. However, some new people have been hired and this should be resolved in 1984.

C. Delay has been experienced in receiving some supplies ordered at CNPAF. Every attempt will be made to transfer funds to CNPAF from UW as quickly as possible.

D. Inability to get equipment items to Brazil has occurred. This is not a major constraint and, hopefully, it is being resolved.

E. Considerable red tape exists in the budget process between MSU and UW. This process takes an undue amount of the US PI's time. As many of these matters should be straightforward, this is frustrating.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

A. Training--Most of this year's training objectives are being met.
   1. Mr. Pedro A. A. Pereira has begun graduate studies toward the M.S. degree at UW.
   2. Ms. Susan Nchimbi from Tanzania is also working toward an M.S. degree in plant breeding and genetics at UW.
   3. Mr. Ricardo Silva Araujo has begun a three-month informal training session at MSU in rhizobiology.
   4. Eighteen students from Bean/Cowpea CRSP projects participated in the three-day BNF workshop at Madison. Judging by comments and feedback, it appeared to be well received and successful.

B. Plant Selection and Improvement
   1. Brazilian materials and UW breeding populations are being screened at CNPAF in a three-stage program. A large group of colored bean materials have passed through the second stage and data are being analyzed.
   2. Inbred-backcross lines developed at UW for Brazil have passed the third stage and the best lines, e.g., UW 22-34, are being evaluated in specific experiments such as intercropping and prepared for regional trials. Some development of new populations for Brazil has been carried out, but on a limited scale. There are currently enough materials available for evaluation.

C. Rhizobium Collection and Evaluation

1. Rhizobium phaseoli Culture Collection

a. Recommended strains obtained from other culture collections:

127K17 (Nigeria)
TAL 182 (NifTAL)
KIM-5 (WSU)
J50 (EMBRAPA, Goiânia--Araujo)
RP132-50 CIAT 57 from North American Plant Breeders

b. The highest fixing strain of 66 Brazilian isolates examined on line 21-58 under growth chamber conditions was strain 45 from Dr. Dazzo's collection.

c. Mr. Ricardo Araujo from CNPAF/EMBRAPA is at MSU this fall and will be making antibiotic-resistant derivatives of each of the above six strains for use in field studies in Brazil.

2. Isolations of Native R. phaseoli for Use in Competition Studies in the Future--A total of 215 nodules from 27 bean hosts from Goiania and Rio de Janeiro were processed and their contents isolated in pure culture. Of these plants, 22 were from uninoculated plots and 5 were inoculated. Using the flask technique with nitrogen-free agar substratum, 100 isolates were inoculated under bacteriologically controlled conditions on P. vulgaris line UW 21-58. Of 79 isolates analyzed to date, 66 (82.5%) were confirmed as R. phaseoli by nodulation within 4 weeks of incubation. All isolates which nodulated fixed nitrogen to varying degrees when assayed by the acetylene reduction (AR) technique. Nodule number, nodule mass, plant dry weight and AR values are being tabulated. Strain 45 is the most effective of this new collection identified to date (see item 1. b., above). This work was done by two part-time aides, Ms. Debora Barnes and Mr. Charles Yokoyama.

D. Factors Affecting N_2-Fixation--An experiment involving growth of bean lines in the same soil in the field and greenhouse was designed to study nodule development and senescence. It is nearing completion as of September 30, 1983 and results will be presented in the next annual report.

E. Dissemination of Results--Plant materials have been sent to the Mexico/MSU project and inoculum and information to the Dominican Republic/Nebraska and University of Puerto Rico projects. Dissemination of methods and techniques has been made through the BNF Student Trainee Workshop. Contact Dr. Fred Bliss for these materials.

X. BASELINE DATA

Little baseline data have been collected to date. However, secondary data are being assembled in Brazil as they become available. Contact with CIAT will be made to obtain any information they may be collecting.

At CNPAF, inoculation of bean seeds with Rhizobium inoculant is being promoted among farmers. In conjunction with this, a questionnaire is being sent to farmers and the resulting information will provide baseline data.

XI. FUTURE PLANS

A. Proposed Changes
1. Project Objectives--Ph.D. training in rhizobiology for a Brazilian student at MSU is not now anticipated.
2. Personnel Changes--No major changes are anticipated.
3. Relocation--None.
4. Project Strategies--Two major strategy changes were developed when the US PI visited CNPAF in October, 1983.
   a. Because of the interest by the CNPAF breeder, Dr. María José Zimmerman, to incorporate breeding for improved BNF into her program and to work closely with this project, less population development will be done at UW.
   b. Because of the large volume of data analyses being generated at CNPAF, it is anticipated that Dr. Henson and others there will not have time to complete the analyses as well as maintain field and lab research. Computer printouts will be sent to UW where a part-time student will be hired to work closely with the PIs to summarize the data.

B. Proposed Plan of Work for FY 84
1. United States
   a. UW
      (1) Administration and coordination of the project.
      (2) Thesis research project developed and initiated by Mr. Pedro A. A. Pereira.
      (3) Data analyses and compilation.
      (4) Development of a limited amount of breeding materials.
   b. MSU
      (1) Non-degree training of personnel in rhizobiology.
      (2) Continued collection and evaluation of R. phaseoli cultures.
      (3) Studies on nodule development and senescence.
      (4) Studies on the basis of effects of intercropping on nodulation.
2. Brazil
   a. Leucaena/bean intercropping (October, 1983-January, 1984)--Explore new ways to promote greater and more stable bean production in mixed cropping systems and compare N_2-fixation in monoculture vs. intercropping.
   b. Maize/bean relay cropping (February-May, 1984)--Determine the effect of maize on bean N_2-fixation parameters and seed yield. Standard cvs and high fixing selections will be compared in different relay cropping combinations.

c. Evaluation of colored beans (3rd stage) (February-May, 1984)--Evaluate the best 20-30 lines from stage 2 for AR, vegetative growth, root dry weight and seed yield. Best selections will be used in future breeding work as recurrent or donor parents.

d. Brazilian N_2-Fixation Network Experiment and International Network of Legume Inoculation Trials (February-May, 1984)--Participate in the wide evaluation of R. phaseoli strains and bean host lines throughout Brazil.

e. Evaluation of new bean lines (stage 1 of new group) (June-September, 1984)--Approximately 300 new lines from Brazil, CIAT, UW and elsewhere will be evaluated for promising lines to pass to stage 2 tests.

Improved Techniques for Development of Multiple Disease Resistance in *Phaseolus vulgaris* L.

I. PROJECT ROSTER

A. US Lead Institution: University of Wisconsin (UW), Madison

Principal Investigator:	Dr. Donald J. Hagedorn, Deparment of Plant Pathology, UW
Postdoctoral Research Associate:	Dr. Debra Ann Inglis, Department of Plant Pathology, UW
Specialist:	Mr. Robert Rand, Department of Plant Pathology, UW
Technical Assistant:	Mr. Eric Carlson, Department of Plant Pathology, UW

B. Brazil Counterpart Institution: Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)

Principal Investigator:	Mr. A. Sartorato, Centro Nacional de Pesquisa Arroz e Feijão (CNPAF), EMBRAPA
Co-Investigators:	Mr. C. A. Rava, CNPAF, EMBRAPA Dr. Josias Fária, CNPAF, EMBRAPA Mr. Marcelo Teixeira, CNPAF, EMBRAPA

II. PROJECT OBJECTIVES

A. First Year (July 7-September 30, 1982)

1. Begin training of Brazilian scientists and graduate students.
2. Initiate research on superior techniques for producing and applying inoculum of the most important disease inciting pathogens.
3. Collect bean strains which are promising for disease resistance, yield potential and high quality.
4. Locate efficient and effective disease testing sites and begin testing their reliability.
5. Collect pathogens for pathogen variability studies.

B. Second Year (October 1, 1982-September 30, 1983)

1. Accelerate and improve the research on superior techniques for producing and applying inoculum of bean pathogens and investigate the importance of pathogen variability and screening techniques to developing lines with durable resistance.

2. Study the bean germ plasm and cv collections, including the useful materials developed by CIAT, Mayagüez Institute of Tropical Agriculture (MITA) and other groups, for multiple disease resistance (MDR) using the developed techniques. Sites in Brazil will be used and cooperation with other research centers for testing sites will be sought, if necessary, for adequate evaluation of certain pathogens.
3. Intensify the research aspects of graduate student training.

III. CHANGES IN OBJECTIVES--None

IV. RESEARCH OUTPUTS

A. Available For Immediate Use--None.

B. Available for Use within 1-2 Years--New and more efficient methods for screening beans for resistance to the diseases anthracnose (*Colletotrichum lindemuthianum*), angular leaf spot (ALS) (*Isariopsis griseola*) and common blight (*Xanthomonas phaseoli*) using dry inoculum produced naturally on diseased bean plants.

V. TRAINING OUTPUTS

None--No Brazilian student has been sent by CNPAF.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. United States

1. Dr. Julio López-Rosa
   Dr. George Freytag
   Dr. James Beaver
   University of Puerto Rico and MITA
   Mayagüez, Puerto Rico

2. Dr. James Steadman
   Dr. Dermot Coyne
   University of Nebraska
   Lincoln, NE

3. Dr. M. J. Silbernagel
   Washington State University, Irrigated Agriculture Research and Extension Center
   Prosser, WA

B. International

1. Drs. S. K. and T. Mohan
   Fundacão Instituto Agronomico do Paraná (IAPAR)
   Londrina, Paraná, Brazil

2. Dr. Aart Van Schoonhoven
   Dr. Steven Temple
   Dr. M. A. Pastor-Corrales
   CIAT, Cali, Colombia

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States

1. Organizational--The Department of Plant Pathology, UW.
2. Administrative--The College of Agriculture and Life Sciences Research Administration, UW.
3. Human--PI 40% time
   - Research Specialist 50% time
   - Secretary 05% time
   - Superintendent, Hancock Experimental Farm 01% time
   - Greenhouse Supervisor 01% time
   - Budget and Fiscal Specialists 01% time
4. Physical--Research Laboratories (1 1/3)
   - Offices (1 1/3)
   - Four-bench 22 x 40-foot greenhouse (1)
   - Station Wagon Automobile (.6)
   - Experimental Fields (2)
5. Financial--The human contributions listed above total $54,484.00.

B. Additional support to the project was provided by CNPAF.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Technical--None.

B. Socio-Political--None.

C. Financial--None.

D. Administrative

1. This project was not approved until May, 1982--too late for full blown field plots. As critical field experiments had to wait until 1983, complete data for only one year are available.
2. Requests for major equipment purchases and international travel are far too long in processing.
3. In Brazil there are major administrative constraints to hiring temporary personnel, equipment purchases and travel. In addition, the subagreement with CNPAF requires them to spend money for research before reimbursements can be spent. They do not have much money to spend so not very much can be sent to them.
4. There have been problems in establishing a functioning communications flow.

E. Human

1. No US human constraints have been experienced.
2. In Brazil the bean researchers initially have been less active than anticipated with regard to this research project, presumably because of indecision concerning research procedures. Happily, substantial improvement appears to be underway.

F. Physical-Logistical--None.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

Cumulative--From July 7, 1982 to September 30, 1983

A. Wisconsin

1. To provide background and guidance experience and data for the summer 1983 field experiments, twelve large and ten modest-sized experiments in the greenhouse, five controlled growth chamber studies, two large and ten small laboratory researches were conducted. Then at selected disease testing sites on two UW Experimental Farms during the 1983 growing season, five elaborate and scientifically designed inoculation experiments were carried out to study methodology with "natural" dry inoculum of the pathogens inciting bean anthracnose, common blight, rust and ALS. Also undertaken were inoculation studies with the Bean Common Mosaic Virus (BCMV).
2. A successful field plot design was developed using border rows of oats and field corn to prevent cross treatment and plot-to-plot contamination. A susceptible and a resistant bean cv were planted in each plot to determine if known disease reactions would occur using the new inoculum and inoculation methodology for each pathogen.
3. An accurate technique for assessing disease severity was devised. It involved sampling plants at three times and rating leaves and pods of each sample plant. For summer research this amounted to approximately 115,000 leaves!
4. Methods to produce, collect, store, quantify and apply "natural" dry inoculum of Colletotrichum, Xanthomonas and Uromyces have been developed. Especially promising is the application of Colletotrichum and Isariopsis to the foliage and application of Xanthomonas inoculum to the seed.
5. Promising results were obtained when collections of bean cvs and strains from Brazil, Colombia, Nebraska and Washington were greenhouse tested for reaction to one or more pathogens. Progress has also been made in building up a collection of isolates of the bean pathogens for studying pathogen variability. Isolates have been obtained from Brazil, Wisconsin, Washington and Michigan.

B. CNPAF

1. Field inoculation studies using several inoculation combinations with the important bean pathogens inciting common bacterial blight (Xanthomonas phaseoli), rust (Uromyces phaseoli), ALS (Isariopsis griseola) and anthracnose (Colletotrichum lindemuthianum) were undertaken. The rather low disease indices for the three Xanthomonas inoculum sources were very likely obtained because the environmental conditions at inoculation time were not

adequate for severe disease development; natural rust infections made evaluations difficult. There was a noticeable amount of initial advantage by using greenhouse-grown dry inoculum of Uromyces.

2. Collections of many bean cvs and strains were tested (1,500 in the field, 350 in the greenhouse) for reaction to several bean pathogens with promising results. Very good progress has also been made in the collection of large numbers of fungus isolates for pathogen variability researches.
3. A satellite location for efficient bean anthracnose (Colletotrichum) research has been arranged in the state of Parana.
4. These promising new techniques for more efficiently determining the reaction of beans to very important devastating diseases give hope that breeders will be able to more expeditiously develop new disease resistant beans with the result that production, especially for the subsistence farmer, will be substantially increased and stabilized.

X. BASELINE DATA--None

XI. FUTURE PLANS

A. Proposed Changes
1. Project Objectives--None.
2. Personnel Changes--None.
3. Relocation--Additional location contemplated; see below.
4. Project Strategies--Considering the potential positive impact of this research project on new bean cv development with subsequent benefit to bean growers, especially subsistence farmers, it is important to explore the possibilities of researching these new bean disease testing techniques in more than one location in developing countries. Such research would provide important additional data on the adaptability of this new methodology to other geographic areas.

B. Proposed Plan of Work for FY 84
1. United States
   a. Develop improved methods for quantifying the bean pathogens in dry "natural" inoculum.
   b. Study the inoculum potential of various types of natural inoculum.
   c. Research the persistence of Colletotrichum, Xanthomonas and Isariopsis in natural, dry inoculum. Study the persistence of Isariopsis in the field. Initiate research on the development of a selective medium for Isariopsis.
   d. Begin work on the development of a multiple inoculation schedule for the five bean pathogens.
   e. Confirm 1983 field test results in 1984 field plots and, at the same time, explore the effect of early, mid-season and late inoculations on disease development and yield loss.

2. CNPAF
   a. Repeat the field inoculation experiments which compared the effectiveness of pathogen inoculum from several sources and include some of the techniques shown to be successful by the Wisconsin research.
   b. Continue to test collections of bean strains for resistance to bean pathogens, including large-scale studies on bean anthracnose at the satellite testing site in Parana.
   c. Initiate the study of bean pathogen variability using the collection of isolates and races made this past year.

Pest Management Strategies for Optimizing Cowpea Yields in Cameroon

I. PROJECT ROSTER

A. US Lead Institution: University of Georgia (UG)

Principal Investigator:	Dr. Richard B. Chalfant, Department of Entomology, UG
Co-Principal Investigators:	Dr. J. A. A. Renwick, BTI
	Dr. P. R. Hughes, BTI
Research Associate:	Dr. Frank Messina, BTI

B. Cameroon Counterpart Institution: Institut de la Recherche Agronomique (IRA)

Research Associates:	Dr. Moffi E. Ta'Ama, IRA
	Mr. George Ntoukam, IRA

II. PROJECT OBJECTIVES

A. United States
1. Identify behavior modifying chemicals' potential for management of major cowpea insect pests.
2. Characterize the chemical and ecological nature of plant resistance.

B. Cameroon
1. Identify key cowpea insect pests and their biology within the principal cowpea producing areas of northern Cameroon.
2. Evaluate cowpea cvs for resistance to major insect pests and characterize the mechanisms for resistance to facilitate breeding for resistance.
3. Identify factors within cropping systems which affect insect-plant relationships.
4. Develop and evaluate pest management methods suitable for small farmers in northern Cameroon.
5. Train Cameroonian students and technicians for entomological research.

III. CHANGES IN OBJECTIVES--None

IV. RESEARCH OUTPUTS

A. Available for Immediate Use
1. Two medium maturing, high yielding, insect and disease resistant cvs obtained from IITA, TVX 3236 and VITA 7, performed well in

Cameroon. These varieties showed less loss of yield due to insects than did local varieties in plots not receiving insecticides.

2. Data were collected on seasonal occurrence and sampling methods were developed for the major insect pests.
3. Effective insecticides against the major insect pests are available.
4. An electrostatic insect sprayer was slightly less effective than a conventional sprayer but required no water--a distinct advantage in semiarid areas.
5. A relationship between the number of insecticidal applications (decamethrin + monocrotophos) and yield increase was obtained. The maximum benefit, based upon cost/benefit analysis, was obtained with three treatments.
6. Data were obtained on the adaptation and performance of local and improved cowpea cvs in various locations in northern Cameroon.
7. Information was gathered on the ovipositional habits and preference of the cowpea weevil which will be very useful in a varietal screening program. It was found that females preferred to oviposit on exposed seeds with smooth surfaces and on green pods.
8. Cowpea weevil larvae suffered high mortality if the seed separated from the pod wall. The "loose seed" trait can be used for resistance selection.
9. Since most weevil infestations begin on green pods in the field and are unlikely to start de novo during storage, prevention of infestation prior to harvest or eliminating beetles immediately after harvest may be critical for achieving control in storage.
10. There is already a great demand for cowpea seeds and expertise from research associates, agricultural development societies (SODECOTON, SEMRY, the Sacred Heart Mission) and farmers (Lake Chad area) in Cameroon.

B. Available for Use within 1-2 Years

1. Identification of insect resistant cowpea cvs with locally desirable seed types.
2. Identification of optimum dates of planting for different areas in northern Cameroon.
3. Effect of sorghum/cowpea interplanting on yields and insect populations.
4. Optimum and judicious use of available insecticides in northern Cameroon.
5. Baseline data on economics and the use of cowpeas in northern Cameroon.
6. Information on conditions which produce flying forms of cowpea weevils, thus allowing for prediction of population outbreaks under particular conditions.
7. Identification of the oviposition deterring pheromone for the cowpea weevil which may have use as a pest management strategy.

V. TRAINING OUTPUTS

A. United States--Degree and Non-Degree Training--None.

B. Cameroon
1. Degree Training--Efforts are underway to enroll Mr. George Ntoukam from IRA in an M.S. program in entomology at UG.
2. Non-Degree Training--None.

C. Other Developing Countries
1. Degree Training--None.
2. Non-Degree Training--An African graduate student, enrolled in the Department of Horticulture at UG, participated in the BNF Student Trainee Workshop in Madison, Wisconsin, July 18-20, 1983.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. United States--National and International
1. The US PI has become a member of the US Vigna Crop Advisory Committee.
2. Linkages have continued with universities in cowpea producing states including experiment stations in Florida, South Carolina, Alabama and the USDA Vegetable Breeding Lab, Charleston, SC.
3. Contacts have been maintained at EMBRAPA with Dr. Daoust, entomologist, and Dr. Watt, cowpea breeder. Relationships also exist with IITA, SAFGRAD and GERDAT (Paris, Montpellier, France). Linkages exist with the Botswana/CSU (deMooy) and the Brazil/BTI (Roberts) projects.

B. Cameroon--Linkages have been established with:
1. Regional Crop Protection Training Center, Yaounde.
2. National Cereals Research and Extension Project (a USAID, IITA, IRA project).
3. Seed Multiplication Project, Maroua and Garoua.
4. SODECOTON (cotton production cooperative with responsibilities for food crop production) Maroua, Garoua.
5. SEMRY (rice cooperative).
6. Catholic Order of Sacred Heart, Mokolo.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States
1. UG Coastal Plain Experiment Station, Tifton.

Professional--Dr. R. B. Chalfant	25% of time
Technicians--Two totaling	53% of time
Clerical--Three totaling	20% of time

2. BTI
   Professionals--Dr. J. A. A. Renwick 25% of time
   Dr. Pat Hughes 15% of time

B. Cameroon
   1. IRA
      a. Plot land; ca 30 acres in Maroua, Garoua, Guetale, Makebi Tchatibali and Wassande.
      b. Laboratory/office; ca 2000 sq. ft.
      c. Two vehicles, one full-time, one shared.
   2. SODECOTON--Plot land at one location.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. There is a lack of insect resistant cowpea cvs with locally suitable seed color.

B. A cowpea breeder is not available in Cameroon to advance and adapt suitable varieties for local conditions.

C. Resources (financial, time and human) are insufficient to adequately cover the major cowpea producing areas in northern Cameroon.

D. Difficulty has been experienced in obtaining essential equipment, particularly that of non-US origin.

E. Lack of a trained secretary at Maroua impedes English language correspondence, filing, reports and data processing.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

Only data from 1982 have been processed.

A. Current Year--The cowpea harvest has been in progress and data will not be available until 1984. Most studies were modifications of those in 1982 in order to confirm results. Observations made in September, 1983 are as follows:
   1. Field plots were in excellent condition and research was progressing well.
   2. Cvs Ife Brown and TVX 3236 obtained from IITA were well adapted to conditions in Cameroon, produced excellent yields and were moderately resistant to thrips.
   3. Current pest management strategies include insecticides of low mammalian toxicity to control major cowpea pests. The Electrodyn electrostatic sprayer has been found to be as nearly effective as conventional moderate-to-high volume sprayers and requires no water, a distinct advantage in semiarid northern Cameroon.

4. Information on the ovipositional habits of the cowpea weevil indicated that varieties with rough seeds and/or showing a "loose seed" trait could be used for screening for resistance. Also, preventing infestations of beetles before harvest or eliminating beetles immediately after harvest may be critical for achieving control.
5. Progress has been made in identifying the oviposition deterring pheromone or "spacing mechanism" of the cowpea weevil.
6. At least three different bruchid species plus a curculionid species were found to attack field cowpeas.
7. An unidentified parasitoid wasp, a potential natural enemy of the cowpea weevil, was collected in large numbers from cowpeas in storage.

B. Cumulative to Date

1. At least three cowpea cvs from IITA show sufficient resistance to disease and insects for further consideration in the program.
2. Improved early maturing varieties Ife Brown and TVX 3236 from IITA can produce adequate yields with a minimum amount of insecticidal protection. These varieties respond less to insect attack than do locals.
3. Insecticides of low to moderate mammalian toxicity are available for effective control of the major cowpea insects.
4. Differences in spray volumes of from 100 to 500 l/ha do not appear to affect insecticidal performance.
5. Insecticidal applications increase yields but more than three treatments are not cost effective.
6. Various vegetable and mineral oils are equally effective in preventing pea weevil infestation of stored seeds but only effective for ca 30 days.

X. BASELINE DATA

Acquisition is in progress under the guidance of Dr. Emmanuel Atayi, Director of the National Cereals Research and Extension Project in Cameroon.

XI. FUTURE PLANS

A. Proposed Changes

1. Project Objectives--None.
2. Personnel Changes--A replacement in Cameroon for counterpart George Ntoukam who is coming to the US for graduate study.
3. Relocation--Expansion of studies to include the northwestern area around Bamenda, Cameroon.
4. Project Strategy and Changes--None.

B. Proposed Plan of Work for FY 84

1. United States
   a. At BTI, three bruchid resistant varieties have been obtained from IITA in Nigeria. Research questions are: does resistance apply equally to genetically different beetle strains and can a strain overcome resistance after many generations of selection?
   b. An aphid resistant cowpea variety has been obtained and the basis for resistance will be studied.
   c. The potential use of parasitoid wasps for control of bruchids in storage will be investigated.
2. Cameroon
   a. Continue screening of cowpea varieties for insect resistance and local adaptation.
   b. Evaluate new insecticides, particularly those with low mammalian toxicity (biologicals, pyrethroids) and application methods.
   c. Continue studies of seasonal occurrence, sampling methods and economic thresholds for major insect pests.
   d. Continue the cowpea/sorghum intercropping experiment with modifications in design.
   e. Develop linkages with other cowpea improvement projects including those of the Bean/Cowpea CRSP in order to obtain new germ plasm.

Biology, Epidemiology, Genetics and Breeding for Resistance to Bacterial and Rust Pathogens of Beans (*Phaseolus vulgaris* L.)

I. PROJECT ROSTER

A. US Lead Institution: University of Nebraska (UNE)

Principal Investigator:	Dr. Dermot P. Coyne, Department of Horticulture, UNE
Co-Principal Investigator:	Dr. J. R. Steadman, Department of Plant Pathology, UNE
Investigator:	Dr. Anne Vidaver, Department of Plant Pathology, UNE
Technicians:	Ms. Cheryl Campbell, Department of Horticulture, UNE
	Mr. Larry Einemann, Department of Plant Pathology, UNE
Administrators:	Dr. R. Kleis, Dean, International Programs, UNE
	Dr. M. Boosalis, Head, Department of Plant Pathology, UNE
	Dr. R. D. Uhlinger, Head, Department of Horticulture, UNE
	Mr. Carl Mueller, Manager, Grants and Contracts, UNE

B. Dominican Republic Counterpart Institution: Secretaría de Estado de Agricultura (SEA)

Principal Investigator:	Dr. César V. Paniagua, Coordinator, National Legume Program, SEA
Plant Pathologist:	Ing. Alfonsina Sánchez, SEA
Assistant:	Lic. Estela C. Peña, SEA
Plant Breeder:	Ing. Zenón Mateo, SEA
Assistants:	Agrón. Fernando Oviedo, SEA
	Agrón. Mercedes Rodríguez, SEA
Secretary:	Ms. Martha Cintron, SEA
Administrators: (Santo Domingo)	Ing. Leovigildo Bello, Sub-Secretary of State for Agriculture, SEA
	Ing. Rafael Martínez Richiez, Director, Departamento de Investigaciones Agropecuarias, SEA
	Lic. Elfrida Pimentel, Director, Centro Sur de Desarrollo Agropecuario (CESDA)
	Dr. Marion Ford, USAID

II. PROJECT OBJECTIVES

Second Year (1982-1983)

A. Survey and determine sources of primary inoculum of bacterial pathogens in the Dominican Republic.

B. Initiate survival studies under Dominican Republic field conditions.

C. Continue screening bean genotypes for reactions to the bacterial and rust pathogens isolated from the Dominican Republic. Identify bean genotypes that have useful levels of non-specific resistance to rust.

D. Develop an improved methodology to select for non-specific resistance (Nebraska) and test identified resistant material in the field (Dominican Republic).

E. Continue with the hybridization program as indicated under the first year activities.

III. CHANGES IN OBJECTIVES--None

IV. RESEARCH OUTPUTS

A. Available for Immediate Use

1. Sources of resistance to Dominican Republic strains of common blight and rust have been identified and are being used in a breeding program to develop resistant cvs.
2. There is no interaction between the pathogens causing rust and common blight diseases. That, combined with basic knowledge on the inheritance of resistance to rust and common blight, will facilitate the use of an effective breeding strategy for combined resistance to both pathogens. The identification, genetics and use of the hypersensitive reaction (HR) to common blight is a new finding.
3. The confirmation of a genotype x common blight interaction indicates the necessity for more testing of new promising lines against a wide array of Dominican Republic isolates.
4. New laboratory facilities and screenhouses are available for plant pathology, breeding and genetic research in the Dominican Republic.

B. Available for Use within 1-2 Years

1. Seed of new improved black and white disease resistant varieties should be available for small farmers. It is now being increased.
2. Improved pinto lines should be available for initial increases and large pilot testing.

3. Additional basic information on the genetics of resistance to rust and common blight should be available to improve the selection strategy for resistance.
4. Two young Dominican Republic scientists, presently enrolled at the UNE, will have completed M.S. degrees. They will provide additional expertise to the Dominican Republic program.

V. TRAINING OUTPUTS

A. United States
1. Degree Training--Mr. Douglas Hindman, who is supported by Bean/Cowpea CRSP funds, and Ms. Luann Finke are enrolled in M.S. programs.
2. Non-Degree Training--None.

B. Dominican Republic
1. Degree Training--Mr. Eladio A. Santana and Mr. Wenceslao Ramírez, both supported on CRSP funds, are pursuing M.S. degrees at the UNE.
2. Non-Degree Training--Mr. Santana and Mr. Ramírez took part in the BNF Workshop in Madison, Wisconsin, July 18-20, 1983.

C. Other Developing Countries
1. Degree Training--Mr. Ahmed Aggour, a Peace-Fellow from Egypt, is in the first semester of Ph.D. work. Mr. Henry K. Leyna, supported by USAID from Tanzania, is in his final semester of Ph.D. studies.
2. Non-Degree Training--None.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. United States
1. International cooperative research has been established with CIAT, the University of Puerto Rico (UPR, Mayagüez) and IAPAR on rust and common blight. This research is based on joint planning meetings and on other forms of communication.
2. Linkages have also been established with other US cooperators through joint planning meetings held under the auspices of the Western Regional W-150 project and Bean Improvement Cooperative (BIC).

B. Dominican Republic
1. The Bean/Cowpea CRSP project in the Dominican Republic has become a part of the National Bean Research Program so that effective use is made of resources and personnel.
2. The Dominican Republic PI has developed effective cooperation with CIAT research personnel.

3. Project personnel have been active participants in the annual meetings of the PCCMCA.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States
1. Ms. Cheryl Campbell (.30 FTE) and Mr. Larry Einemann (.20 FTE), paid by the UNE, work on this project.
2. Mr. David Nuland, Scottsbluff, Nebraska, and Dr. Dale T. Lindgren, North Platte, Nebraska, conduct cooperative work of value to the project.
3. See section V for oetails on graduate student involvement.

B. Dominican Republic
1. Eight scientists in the National Program interact or are involved in the project ($15,000, 1983-84). The project has been incorporated into the National Bean Program which increases its strength and value.
2. The Dominican Republic provides an accountant, technical assistants and laborers for the project.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. The long delay required to obtain AID travel approval is a serious restriction.

B. Objectives 1 and 2 in the original proposal have been delayed because of Dr. M. L. Schuster's resignation and the current lack of trained personnel in plant pathology in the Dominican Republic. Ing. A. Sánchez has now obtained training in bacteriology. Dr. Anne Vidaver (bacteriologist, UNE) has now replaced Dr. Schuster.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

A. Current Year
1. United States
a. Common blight-strain testing-resistance--A genotype x isolate interaction was observed (similar to the previous year with other isolates) indicating the importance of evaluating parents and advanced lines with a wide array of isolates in order to identify lines with broad resistance. GN Nebr. #1 sel. 27 and PI 207265 had the highest level of resistance. In addition, interactions occurred between cv x concentration, isolate x concentration and cv x isolate x concentration. Different resistant cvs responded differently depending on the isolate and concentration used. This complicates the evaluation process. Brazilian pinto line BAC-6 showed high resistance.

b. Common blight-genetics--A HR was detected using the multiple needle method of inoculation with some sources of resistance and was found to be simply inherited. The tolerant reaction, expressed with other methods of inoculation, is under polygenic control making selection more difficult. The HR should improve selection efficiency. The independent genetic control of the leaf (tolerant) and pod reaction was confirmed. However, the inheritance pattern of the pod reaction showed only slight change with isolates of varying virulence while the leaf reaction showed a marked change.

c. Rust-isolates-resistance--Collections of rust isolates were made in the Dominican Republic during recent visits. Selections within 'Pompadour Checa' possessed resistance to all isolates from the Dominican Republic, Nebraska and Colorado. Other selections within this land-race were susceptible. 'Ecuador 299', 'Mexico 235' and 'Mountain White Half-Runner' were found to be highly resistant. 'Aurora' was resistant to Nebraska and Colorado isolates but was susceptible to Dominican Republic isolates.

d. Rust and common blight-genetics--No interaction occurred between the pathogens inciting these diseases. This indicated that it was satisfactory to study the genetics of resistance to both pathogens simultaneously on segregating populations derived from five crosses.

e. Publications--Twelve manuscripts of various kinds were published or prepared.

2. Dominican Republic

a. Evaluation of breeding lines for adaptation, yield and disease resistance--Ten introductory trials (20 entries) and 6 yield trials (7 entries) and an extensive rust nursery were grown and summarized. MITA-La Vega (black) and BAT-240 (black) performed well overall. BAT-1274 was considered to be the best CIAT pinto line. High rust resistance was observed in Mexico 309, IBRN 95B, IAN 5091 and BAT-41. No satisfactory level of common blight resistance was observed in these field tests.

b. Breeding--Crosses were made in the new screenhouses between Dominican Republic cvs with new germ plasm resistant to rust and common blight. F_2 and F_3 progeny will be grown for evaluation.

c. Facility improvement--A new building containing rooms for a germ plasm bank, a plant pathology laboratory and a room for seed processing and seed preparation was constructed in the Dominican Republic.

d. WID items--Four of the six technical assistants involved with this project in the Dominican Republic are women. The Dominican Republic national program scientist with the project is a woman.

B. Cumulative to Date
1. Two graduate students are now in the second semester of the M.S. program at the UNE.
2. Laboratory and screenhouse facilities have been constructed in the Dominican Republic.
3. One white and two black disease resistant lines have been identified for increase and release.
4. Germ plasm has been identified with resistance to common blight and rust.
5. The importance of genotype x bacterial strain interaction has been demonstrated.
6. The inheritance of resistance in leaf and pod to common blight has been determined.

X. BASELINE DATA

Ing. Sánchez prepared a publication containing important baseline information. A survey of bean producers was conducted. Ms. J. Logan, a UNE graduate student with the International Sorghum/Millet CRSP (INTSORMIL) collected additional baseline data. These data are now being analyzed and are highly relevant to the project.

XI. FUTURE PLANS

A. Proposed Changes--None

B. Proposed Plan of Work for FY 84--Project plans involving cooperative research in the Dominican Republic, at the UNE, UPR and CIAT were developed and approved at a joint meeting of scientists held at Lincoln, Nebraska.
1. United States
a. Graduate student training and research--Mr. Santana and Mr. Ramírez (Dominican Republic) will continue their academic programs for the M.S. degree. Ms. Finke (US) and Mr. Leyna (Tanzania) will write their M.S. and Ph.D. theses, respectively. Mr. Aggour (Egypt) will begin his Ph.D. research (see section V).
b. Postdoctoral research--One scientist will investigate the genetic mechanism and usefulness of small pustule rust reaction, and a second scientist will study epiphytic populations of common blight bacteria on bean leaves of different bean genotypes and on the identification of bean genotypes with reduced bacterial seed transmission.
c. Breeding and genetics--Screening trials will be conducted in the greenhouse to identify sources of resistance to the strains of common blight and rust prevalent in the Dominican Republic and Nebraska. The inheritance of resistance to common blight and flowering will be studied using similar populations grown in Nebraska, the Dominican Republic and

Brazil. The genetic relationship of the HR and the tolerant reaction of some dry bean genotypes will be investigated. Crosses will be made in the greenhouse (Nebraska) between newly identified sources of resistance to common blight with 'Pompadour Checa' (pinto) and 'Venezuela 44' (black) bean types.

2. Dominican Republic
   a. Plans include: Development of clean seed of new breeding lines, screening for resistance to rust and common blight diseases, isolation of strains of X c pv. p, testing advanced bean lines for adaptation, yield and quality. Crosses will also be made between germ plasm possessing resistance to rust and common blight diseases and other desired traits with local 'Pompadour' and black seeded types in order to combine disease resistance with acceptable seed types.
   b. Baseline data collected in the 1983 survey will be summarized and published.

Improvement of Bean Production in the Dominican Republic through Breeding for Multiple Disease Resistance in the Preferred Standard Cultivars

I. PROJECT ROSTER

A. US Lead Institution: University of Puerto Rico (UPR), Mayagüez

Principal Investigator:	Dr. Julio López-Rosa, College of Agricultural Sciences, UPR
Co-Principal Investigators:	Dr. George F. Freytag, USDA, MITA, UPR Dr. James S. Beaver, Department of Agronomy, UPR
Research Assistants:	Lic. Mildred Zapata-Serrano, UPR Lic. Rodrigo Echávez-Badel, UPR
Technician:	Ing. Hirám Vélez-Martínez, UPR

B. Dominican Republic Counterpart Institution: Secretaría de Estado de Agricultura (SEA)

Principal Investigator:	Dr. César Paniagua, Coordinator, National Legume Program, SEA
Research Assistants:	Ing. Manuel Mateo-Solano, SEA Ing. Zenón Mateo, SEA
Technicians:	Agrón. Mercedes Rodríguez, SEA Agrón. Fernando Oviedo, SEA

II. PROJECT OBJECTIVES

A. Produce a MDR bean germ plasm base in order to minimize losses due to diseases and thus provide a cropping security over time in the Dominican Republic.

B. Preserve or improve the agronomic characteristics, yield and quality of the preferred Dominican cvs to assure economic and efficient production of a crop that will meet the acceptance and fulfill the nutritional requirements of the population.

III. CHANGES IN OBJECTIVES

No changes in objectives were made. As indicated in the 1983 Work Plan, the availability of resources (vehicle acquired by the Dominican Republic/University of Nebraska [Coyne] project and additional personnel from SEA to collaborate with the project) made possible the initiation of activities in the eastern (Higüey) and north (Santiago) bean growing regions of the country.

IV. RESEARCH OUTPUTS

A. Available for Immediate Use

1. White seeded bean breeding line 2W-33-2, which has performed consistently well in the Dominican Republic, is being considered for release as a cv in 1984.
2. Breeding lines L-226-10, L-227-1, 3M-150, 3M-152 and 4M-99, which have shown good yield potential and high levels of MDR, were made available through official releases to other breeding programs for use as parents in crossing schemes.
3. An article was prepared on the identification of genotypes with stable yield traits (based on the analysis of 2 years of yield data from 27 locations in the Dominican Republic). The manuscript will be submitted shortly to Crop Science.
4. Baseline data collected in the country is available to help assess the impact of the project on bean production.

B. Available for Use within 1-2 Years

1. White and black seeded bean genotypes with improved levels of resistance to rust and bacterial blight.
2. A Venezuela 44 type bean with the B-190 source of resistance to rust.
3. A Pompadour type bean with the I gene for resistance to BCMV.
4. Erect black and white seeded lines resistant to BCMV, rust and anthracnose.
5. An article on the incidence of bean diseases in the Dominican Republic (based on data from the introduction trials); the manuscript is in preparation.
6. Two articles reporting practical applications of bacterial blight (*Xanthomonas* sp.) research; the manuscripts are in the review process.

V. TRAINING OUTPUTS

A. United States

1. Degree Training--Ing. Hirám Vélez-Martínez is pursuing an M.S. in crop protection at the UPR. He made significant progress toward the completion of course work in his academic program. This is part-time study not supported by the CRSP.
2. Non-Degree Training--Ing. Hirám Vélez-Martínez and Lic. Mildred Zapata-Serrano completed a short course in micro computers. Mr. Rodrigo Echávez-Badel took part in a summer course on micro computers. These three individuals also participated in a bean rust workshop at Mayagüez.

B. Dominican Republic

1. Degree Training--Mr. Miguel A. Martínez-Cruz and Ing. Manuel Mateo-Solano are enrolled in M.S. degree programs at UPR. Mr. Martínez-Cruz is in the final stages of preparing his M.S. thesis

in crop protection. Ing. Mateo-Solano began an M.S. program in agronomy in August, 1983. A third person, Agrón. Fernando Oviedo, is pursuing the Ing. Agrónomo curriculum at the Universidad Nacional Pedro Henríquez Ureña, San Juan de la Magüana.

2. Non-Degree Training--Agrón. Mercedes Rodríguez and Agrón. Fernando Oviedo participated in a three-week training session at UPR/Tropical Agriculture Research Station (TARS) in bean technology. Mr. Miguel Martínez-Cruz took part in the BNF Workshop held at the UW, July 18-20, 1983.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. UPR

1. Intranational--Contacts and cooperative relationships developed with USDA and several state university bean programs (MSU, UNE, UW, Cornell University, University of Florida [UF] and CSU) were maintained and strengthened.
2. International--Collaboration with the CIAT bean program was strengthened. Contacts with PCCMCA were maintained by participation of project personnel in the annual meeting. Germ plasm was exchanged with CNPAF, EMBRAPA.

B. Dominican Republic--Collaborative ties between the project staff and SEA were widened and strengthened.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States

1. UPR--The project continued to have the support of the UPR authorities. The Chancellor of the Mayagüez Campus, the Dean of Agricultural Sciences, the Associate Dean for Research, the Coordinator of International Programs and the Directors of the Departments of Crop Protection and Agronomy and Soils have all contributed their time to the administration of the project. The personnel, budget and finance offices of the Agricultural Experiment Station also shared with the PI important administrative responsibilities. The financial contribution to the project exceeded the required minimum match of 25%.
2. USDA-Agricultural Research Service (ARS) TARS--Part of the time of a bean research geneticist as well as physical resources (offices, laboratory, greenhouses and vehicles) were contributed.

B. Dominican Republic--SEA has administered the personnel and financial aspects and has made personnel and facilities (infrastructure) available.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

No significant constraints affected the achievement of objectives at either UPR or the Dominican Republic. The rapid turnover of administrators in the Dominican Republic with responsibility for the project has not limited progress.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

A. Current Year--Significant progress toward objectives was achieved. The work planned for both phases of the project (UPR and Dominican Republic) was accomplished.

B. Cumulative to Date--Progress toward objectives during the two years and four months of project life has been significant. Consequently, the cumulative record of accomplishments indicates fulfillment of the yearly objectives. See IV, above.

X. BASELINE DATA

Baseline data were acquired from the San Juan de la Magüana Valley, the chief bean producing region of the country. The information, although incomplete, provides a good reference point for estimating the project's impact on bean yield stabilization and production in the area.

XI. FUTURE PLANS

A. Proposed Changes

1. Objectives--No changes in objectives are proposed.
2. Personnel Changes--At UPR, time devoted by Mr. Echávez-Badel was reduced from 50% to 25%. There are plans to hire a full-time technician (B.S. level) to make up for this deficiency and to support the senior project staff. In the Dominican Republic there are plans to engage Mr. Martínez upon his return from graduate school at UPR to work on root problems.
3. Relocation--No relocations are anticipated.
4. Strategies--The project has developed to the point where evaluation of advanced lines in the Dominican Republic should be intensified. Accordingly, the project will emphasize evaluation of *P. vulgaris* for disease resistance. In the breeding program, backcrosses will be made with a Pompadour seed type to increase the probability of obtaining segregants with desirable seed types. Research to identify genotypes resistant to root rots also will be intensified. To increase field work efficiency, the introduction and adaptation trials will be combined into a single trial.

B. Proposed Plan of Work for FY 84

1. UPR Research Activities
   a. Obtain new germ plasm from other programs and scientists and screen in laboratory, greenhouse and field for disease resistance.
   b. Crossing block composed of parents with disease resistance and desired seed types.
   c. Evaluation of F_3 and F_4 from genotypes resistant to bacterial blight and rust.
   d. Continuation of Recurrent Selection Program (RSP) development in *Phaseolus coccineus*.
   e. Cooperative work with researchers interested in crosses with *P. acutifolius* as a source of resistance to bacterial blight.
   f. Evaluation of progenies from crosses of MDR *P. coccineus* x advanced lines of *P. vulgaris*.
   g. Continuation of efforts to characterize the nature of rust resistance to B-190.
   h. Continuation of work with IVT lines as sources of minor gene protection for the I gene to BCMV.
   i. Advanced line yield trial at the Isabela and Fortuna Substations.
   j. Crosses to transfer the I gene for BCMV resistance into Pompadour.
   k. Continuation of testing of selected *P. coccineus* hybrids for resistance to Bean Golden Mosaic Virus (BGMV), BCMV, Cowpea Mosaic Virus (CpMV) and *Xanthomonas*.
   l. Continuation of characterization of BCMV necrotic strain.
   m. Reinoculation of the *P. acutifolius* population and reselection for resistance to *Xanthomonas*.
   n. Characterization of *Xanthomonas* isolates from Fortuna.
2. Dominican Republic Research Activities
   a. Initiation of root rot studies.
   b. Backcrosses to incorporate rust resistance from B-190 into Venezuela 44.
   c. Replicated trial during the warm and humid season with some of the most promising F_4 lines from crosses of bacterial blight resistant x rust resistant genotypes.
   d. Combination of introduction and adaptation trials into a single trial.
   e. Yield trials with genotypes with potential for release.

C. Training

1. Degree Training at UPR--Completion of requirements for the M.S. degree by Mr. Miguel A. Martínez-Cruz, continuation of the M.S. program by Ing. Manuel Mateo-Solano, initiation of an M.S. program by a Dominican Republic student yet to be identified.
2. Non-Degree Training--Short course in bean technology at UPR for project technician, Ing. Zenón Mateo.

Agronomic, Sociological and Genetic Aspects of Bean Yield and Adaptation

I. PROJECT ROSTER

A. US Lead Institution: Cornell University

Principal Investigator:	Dr. Donald Wallace, Department of Plant Breeding, Cornell University
Co-Prinicipal Investigators:	Dr. Roger Sandsted, Department of Vegetable Crops, Cornell University
	Dr. Patricia Garrett, Department of Rural Sociology, Cornell University

B. Ecuador Counterpart Institution: Instituto Nacional de Investigaciones Agropecuarias (INIAP)

Principal Investigators:	Ing. C. Villacís, Director, Legume Program, INIAP
	Ing. C. Chiriboga, Legume Program, INIAP
Agricultural Economist:	Ing. Patricio Espinosa, Head, Planning Division, INIAP
Agronomist:	Ing. Venus Arévalo, INIAP
Sociologist:	Ms. Donna Goldstein, Cornell hired US researcher working at INIAP

II. PROJECT OBJECTIVES

A. Determine the biological, environmental, economic and social roles of bean production in the farming systems of small farms.

B. Develop methods of determining the merit of potentially useful bean production practices using research conducted under the management system and the environment of small farms.

C. Determine which crops in bean intercropping systems compete the most or provide the highest return from the application of limited resources such as fertilizer.

D. Develop credible procedures for measuring (or estimating) the degree of acceptance of potential new practices by small farmers and determine the merit of the feedback of such information in establishing research objectives.

III. CHANGES IN OBJECTIVES--None

IV. RESEARCH OUTPUTS

A. Available for Immediate Use--Short-term objectives have focused on developing an appropriate and economical methodology for farming systems research. Interview schedules were designed and micro computer techniques developed. The interview schedules orient farming systems research in study regions. Two instruments have been developed and their strengths and weaknesses evaluated.

1. Structured Interviews with Informants--An outline for structured interviews in which respondents report not on themselves but on practices in the area was developed. A joint INIAP/Cornell team conducted research in four zones of Imbabura Province. Written outputs of this work include an interview guide in three languages, one substantial team report and three specialized reports by an agronomist, an anthropologist and a sociologist.
2. Interviews with a Statistically Representative Sample--An applied questionnaire was developed in Pimampiro where small-scale, commercial bean production is important. From a list of all landowners, a micro computer program was used to pull a stratified random sample. Thirty-seven landowners were interviewed during May and June, 1983.

Restudy of Pimampiro identified strengths and weaknesses of the two data collection procedures. Dr. Garrett and Ms. Goldstein will present a paper on this topic at the project seminar (FY 84) in Quito. A central argument is that structured interviews with informants can provide valid data if analysis of secondary data precedes fieldwork. Appropriate micro computer techniques are necessary to process primary and secondary data.

B. Available for Use within 1-2 Years--Micro computer techniques will strengthen the ability of INIAP and similar institutions to conduct farming systems research. Hardware and software available for Apple II systems have been evaluated and specific recommendations were made to INIAP and ICTA, Guatemala. A fully developed economical and powerful micro computer methodology is anticipated within two years.

1. Project documents include a manual for the analysis of agricultural census data. It is a complete technological package. The manual discusses relevant variables and how they relate to agricultural production. It gives a sequence of tables and guidelines to interpretation. It is accompanied by a program written for this project which calculates a common measure of inequality, the gini coefficient. The manual accompanies the statistical program Apple Interactive Data Analysis. This manual will be used at Cornell to analyze data from Imbabura and at INIAP to analyze Manabí data. It will be revised and an improved version will be available in English and Spanish by September, 1984.

2. The question of how micro computers can be used to identify geographic regions usually called "recommendation domains" is being addressed. This requires the selective transfer of information from maps to micro computers. Depending on available information, relevant data might include altitude, soil type, land use and life zones. Temperature and rainfall data plus site-specific socio-economic data might also be included. It will probably require two years of systematic work to develop the data analysis strategy, test it in the field and prepare a didactic manual. Cornell will continue to work on this issue as part of the overall work plan. Data from Imbabura are being input into a topographic mapping program.

Data from Manabí will be analyzed (January-April, 1984) prior to the initiation of field research in May, 1984. Thus, Cornell, INIAP and ICTA are collaborating in developing a farming systems research strategy that applies micro computers to analyses of agricultural census and environmental data.

V. TRAINING OUTPUTS

A. United States
1. Degree Training--No trainees were supported by the project at Cornell during this last fiscal year. Two male undergraduate students are currently employed working on micro computer applications.
2. Non-Degree Training--Ms. Donna Goldstein, a sociologist with the project in Ecuador, took two courses at the Facultad Latino-americana de Ciencias Sociales.

B. Ecuador
1. Degree Training--INIAP chose not to send staff abroad because several staff members were already receiving training under another Title XII grant.
2. Non-Degree Training--Ms. Venus Arévalo, INIAP, studied English. Legume Program members participated in the design and pretest of the questionnaire in the zone of Pimampiro.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. United States--Dr. Garrett presented a paper entitled "Identifying Target Populations" at the Farming Systems Symposium at Kansas State University (KSU) (November, 1982). She also participated in the pan-CRSP session of the Rural Sociological Society (August, 1983) and discussed consequences for women of the farming systems orientation at the meeting of the Association for Women in Development (AWID) (October, 1983).

B. Ecuador

1. A mechanism was developed by which INIAP could access social science expertise in Ecuador. Contractual relationships were established with CEPLAES, a private research institution. These have since been discontinued. INIAP has organized a national network of on-farm research units (PIP) and coordinated work with regional development programs (DRI). Organizationally, CRSP activities are now linked directly to the PIPs and through them to the DRIs.
2. The CRSP is establishing links between INIAP and ICTA. ICTA will participate in a project seminar scheduled for 1984 in Quito. The theme will be social, agronomic and genetic aspects of bean production in Ecuador and Guatemala. This covers all activities of both CRSP projects. It is also planned that ICTA and INIAP biometry leaders will attend a micro computer session at Cornell. Visits to international centers are under consideration.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States--During this project year, Cornell University supported the CRSP activities fully with primary personnel support and with general office administration and implementation support. Cornell's International Agriculture Program, the PI's respective Department Heads and the Cornell Project Advisory Committee have all contributed to the effort, thereby intensifying Cornell's contribution to progress.

B. Ecuador--Institutional resources remain adequate in terms of primary personnel support for project implementation as well as in terms of general office and field administrative and implementation support. INIAP contributed personnel and general office expenses including one full-time staff agronomist. Despite the severe economic constraints under which INIAP has had to operate in 1982-1983 and will operate in 1983-1984, it is clear that the institutional commitment to the CRSP activities is firm.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. The subcontract between Cornell and INIAP (January, 1983) permitted the transfer of CRSP funds, thereby removing a major constraint to activity.

B. Placement of the CRSP at Cornell under the administrative direction of the International Agriculture Program and the addition of an assistant project coordinator in September, 1983 provided support to implementation.

C. INIAP's administrative personnel underwent changes starting in November, 1982. These included the Director General, Assistant Director General, Director of the Experiment Station and Head of the Legume Program, who is the counterpart PI. These changes strengthened INIAP's ability to collaborate. However, such transitions at both Cornell and INIAP, coupled with economic restrictions in INIAP's budget, interrupted project progress during the first two quarters of 1983. Cornell's involvement with the new Director General, the newly appointed PI and the new Director of the Santa Catalina Experiment Station was delayed when a planned visit (March, 1983) by Drs. Isleib and Wallace was cancelled for lack of timely clearance. By July, planning and limited project activities were again underway (with modifications relative to project plans established in January, 1983).

D. In July, 1983, Drs. Wallace and Sandsted met with all INIAP project staff to discuss project plans and implementation. Dr. Garrett met with them later in July and August of 1983. The INIAP and Cornell staff jointly developed a plan of work for the socio-agronomic research in Ecuador and decided that a sociologist and an agronomist will be employed through Cornell for field placement with INIAP. These plans plus the roles of additional INIAP staff were fully discussed at Cornell in October when the INIAP Director General, Sub-Director, Director of the Experiment Station, and Head of Planning/Agricultural Economics spent five days planning with the Cornell staff.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

Data have been collected using structured interviews with informants and questionnaires with a statistically representative sample. This work has demonstrated that structured interviews and regional analysis can produce valid information, provided there is adequate preparatory work, specifically the analysis of agricultural census and environmental data. These principles were demonstrated by field research and they have applications beyond this project.

In Ecuador, the project has focused on Imbabura, specifically Pimampiro. Several papers about the province and the sub-zone have been written. The study and restudy of Pimampiro has identified researchable problems. Trials are being designed and experiments will be placed on smallholders' fields (March, 1984). The project's genetic component will be introduced at this time. It provides additional criteria for evaluating varieties, but it requires no modification of trials as they have tentatively been designed. The project has, therefore, begun to move beyond diagnostic research to on-farm trials, completing another stage of farming systems research.

X. BASELINE DATA

The project makes extensive use of secondary data. Socio-economic data include agricultural census and published studies about Ecuadorian agriculture. Agronomic data are soils, land use and life zone maps obtained from the planning unit of the MAG. The analysis of these data plus those from the structured interviews conducted in Imbabura (summer, 1982) and the random sample of smallholders interviewed in the sub-zone of Pimampiro (spring, 1983) constitute the baseline. A similar baseline will be developed for all three locations where the CRSP will work. Trials are planned (spring, 1984) for small farms in the sample.

XI. FUTURE PLANS

A. Proposed Changes

1. Project Objectives--During the initial phase, the focus was on the farming systems component. This work has identified researchable problems and INIAP will plant trials in Pimampiro beginning spring, 1984. Data related to the genetic component of photoperiod and temperature sensitivity will be collected at the same time.

   CRSP research in Guatemala and at CIAT has shown that maturity and the adaptations of beans to lowland, moderate elevation and highland tropics are governed for each location by a different set of physiological genetic responses to the geographically different impacting daylength and temperatures. This knowledge suggests different but specific assay and selection strategies be used in breeding for maturity, adaptation and yield at tropical locations below 800 meters with attendant high temperatures, above 1000 meters with low temperatures, and at 800-1000 meters with the optimal 23-25° C temperature that gives flowering and maturity in the fewest days of all environments. This biology of bean maturity (see Guatemala/Cornell University (Wallace) Technical Summary) suggests a further strategy for these temperate zones.

   INIAP will plant trials at different altitudes and collect temperature data. No modifications of experimental design are required, so the farming systems and the genetic components will be complementary.

2. Personnel Changes--Personnel changes have strengthened the institutional links between Cornell and INIAP. The CRSP at Cornell, now closely coordinated by International Agriculture, has an administrative/policy counterpart at INIAP in the Assistant Director General. Ing. Cristobal Villacís replaced Ing. César Chiriboga as the Head of the Legume Program, and Dr. Francisco Muñoz supervises this program under the Santa Catalina

Experiment Station. Ing. Jorge Riovadeniera, National Coordinator of the PIP, joins Ing. Patricio Espinosa, Head of Planning and Agricultural Economics, as a CRSP counterpart. Ing. Venus Arévalo continues working with the project. There will be eleven additional technicians involved in CRSP-related research in 1983-1984. Through Cornell, the CRSP will hire one agronomist and one sociologist for activities in Ecuador. This must be effected by March if activities are to proceed as planned.

3. Relocation--Pre-intervention research in Pimampiro has identified researchable problems for the National Legume Program. Planning for on-farm trials has begun and experiments will be planted in March, 1984. Agronomic and socio-economic evaluation of these trials will occur (August-September, 1984). Socio-agronomic activities will begin (May, 1984) in a new location, Manabí. The analysis of secondary data prior to field work will occur at both INIAP and Cornell. On-farm trials will follow field work. Work in the southern highland location of Cañar/Azuay will not begin before March, 1985. These will be the three zones in which the CRSP will work for in the foreseeable future.

4. Project Strategies--Work to date on the CRSP could be labeled "pre-intervention" research. The most intense work has occurred in Pimampiro where researchable problems have been defined. Trials on smallholders' fields are being designed and will be planted in March, 1984. Technology from the experiment stations will be evaluated from agronomic and socio-economic perspectives. The farming systems component will move beyond baseline research to on-farm trials and technology evaluation. Rather than a change of strategy, this represents a more complete process which began in Pimampiro and will be followed in other zones where the CRSP works.

B. Proposed Plan of Work for FY 84

1. United States--Cornell: During the first semester, Dr. Garrett and Ms. Goldstein will analyze Pimampiro sample data. They will write one paper evaluating the strengths and weaknesses of two data collection procedures and another analyzing the process of capital accumulation in the zone. Under Dr. Garrett's supervision, Ing. Palacios will use the project manual, analyze agricultural census data for Imbabura and write up the results. Mr. Golden, a student employee at Cornell working on micro computer applications, will analyze environmental data from Pimampiro. All materials will be distributed prior to the project seminar. Second semester, Mr. Golden will analyze environmental data for Manabí and prepare a report prior to the initiation of field work (May, 1984).

2. Ecuador--CRSP activities will focus on two regions:
   a. Manabí--Cornell, with the concurrence of INIAP, will hire an agronomic and a social scientist for CRSP research in Ecuador (by March, 1984). INIAP will begin (November-February) the analysis of agricultural census data for Manabi using the manual prepared by Cornell. The agronomic and social scientists will assist in the final stages of data analysis and modification of the interview guide (March). They will run the training session for INIAP staffers and lead the field team in Manabi (May). The team will prepare a written report which will orient future agronomic and socio-economic research in the zone.
   b. Pimampiro--INIAP has developed a tentative plan for experimental research which needs to be reviewed by the TC and implemented during the next planting season (March, 1984). INIAP will hire a technician with CRSP resources and repair the Legume Program's pick-up for work in Pimampiro. The Cornell-hired agronomist will assist in this work, as will the Cornell-hired social scientist. Two seasons of on-farm trials plus periodic socio-economic evaluation will continue for several years.

Agronomic, Sociological and Genetic Aspects of Bean Yield and Adaptation

I. PROJECT ROSTER

A. US Lead Institution: Cornell University

Principal Investigator: Dr. Donald Wallace, Department of Plant Breeding, Cornell University

Co-Principal Investigators: Dr. Patricia Garrett, Department of Rural Sociology, Cornell University
Dr. Roger F. Sandsted, Department of Vegetable Crops, Cornell University

B. Guatemala Counterpart Institution: Instituto de Ciencias y Tecnología Agrícola (ICTA)

Principal Investigator: Dr. Porfirio N. Masaya, Bean Program Leader, ICTA

Co-Principal Investigator: Ing. Selvin Arriaga, Head, Socio-Economic Unit, ICTA

II. PROJECT OBJECTIVES

A. Determine the biological, environmental, economic and social roles of bean production in the farming systems of small farmers.

B. Develop methods of determining the merit of potentially useful bean production practices using research conducted under the management system and the environment of small farms.

C. Determine which crops in bean intercropping systems compete the most or provide the highest return from the application of limited resources such as fertilizer.

D. Develop credible procedures for measuring (or estimating) the degree of acceptance of potential or new practices by small farmers and determine the merit of the feedback of such information in establishing research objectives.

III. CHANGES IN OBJECTIVES--None

IV. RESEARCH OUTPUTS

A. Available for Immediate Use

1. A completed doctoral thesis contributing to research activities is Muhammed, A. F. H., 1983. The Effects of Temperature on Days

to Flower and Maturity in Dry Beans Phaseolus vulgaris L., Cornell University.

2. CRSP research at different elevations in Guatemala and at CIAT demonstrated that the flowering and maturity interactions to daylength and temperature observed in controlled environments do occur in the field. Thus, the world's variations in temperature and daylength exert definable control over bean flowering, maturity, adaptation and yield.

B. Available for Use within 1-2 Years--A 200-page review (Wallace, D. H. 1984. Physiological Genetics of Maturity, Adaptation and Yield) will appear in Plant Breeding Reviews. CRSP and other bean research plus research on another 25 crops is reviewed to derive and describe the biological processes controlling plant maturity and adaptation. The review describes how to use measures of these processes to expedite breeding beans and other crops for specific adaptations to lowland, moderate elevation, highland tropics or temperate zones.

V. TRAINING OUTPUTS

A. United States

1. Degree Training--This year Mr. Paul Gniffke conducted CRSP-related Ph.D. thesis research at CIAT on daylength temperature effects on bean maturity and adaptation. Mr. Gniffke, whose funding comes from the project, plans to complete his thesis in fall, 1984.

   Mr. Kenneth Yourstone, enrolled in an M.S./Ph.D. program in plant breeding at Cornell, has worked on the photoperiod x temperature effects on maturity of 50 genotypes of different origins and adaptations. In 1983 these were grown in 25 plantings positioned around the world. Mr. Yourstone grew and evaluated two plantings at Ithaca. His research provides the only CRSP-related cv adaptation comparison between temperate and tropical zones. Mr. Yourstone, Dr. Wallace and CIAT are seeking support for this and other basic physiological-genetic objectives. Mr. Yourstone has researched temperature x photoperiod effects in the growth chamber and will begin growth chamber studies of maturity gene actions.

   In February, 1983 Dr. Abdullah Muhammed finished four years of growth chamber research on effects of day, night, mean and diurnal differences of temperature on days to flowering, thereby providing much of the theoretical bases for field research progress. The Bean/Cowpea CRSP supported him for one and one-half years. Dr. Muhummad received his Ph.D. from Cornell.

2. Non-Degree Training--Mr. Kenneth Yourstone participated in the BNF Workshop held in Madison, Wisconsin, July 18-20, 1983.

B. Guatemala

1. Degree Training--Three Guatemalan students continued English language training at Cornell and took CRSP-relevant courses in crop production and rural sociology. Because two did not pass the TOEFEL, they returned to Guatemala in May. The third, Mr. Aldaña, began an M.S. in plant breeding at Cornell in May. He collected a summer's data on inheritance of susceptibility vs. moderate resistance vs. near immunity to bean bacterial blight. During the summer, he also worked with BTI plant pathologists. Current plans call for the ICTA agronomist in charge of on-farm bean studies to enter an M.S. program in agronomy in summer, 1984.
2. Non-Degree Training--Mr. Fernando Aldaña attended the BNF Workshop held in Madison, Wisconsin, July 18-20, 1983.

C. Other Developing Countries

1. Degree Training--Mr. Albert Wolokolie, supported by USAID through Cuttington University, Liberia, has done CRSP-related growth research demonstrating control of maturity in lima beans is similiar to that of common dry beans. His work will continue until December, 1983.
2. Non-Degree Training--Dr. T. A. More, a postdoctoral research associate from India, received training and did growth chamber research on effects of diurnal temperature difference or days to flower and flower bud development.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. United States

1. International CRSP travel enabled the PI and Cornell agronomist to maintain contact with CIAT. This facilitated the International Flowering and Adaptation Nurseries planted in 1983 at US, Canadian, Puerto Rican, Guatemalan, Ecuadorian, Belgian, French and Colombian locations. This activity will continue over at least three years without CRSP support. It is supported in the US by the Western Region W-150 project entitled: Breeding Beans for Improved Yield, Pest Resistance and Culinary Quality.
2. Dr. Muhammed, Mr. Yourstone, Mr. Gniffke and Dr. More each reported research progress at the American Society of Agronomy Meetings in Washington, DC, August, 1983.

B. Guatemala

1. In March, 1983 Dr. Masaya presented 1982 CRSP research on maturity and adaptation at the PCCMCA Meetings.
2. Dr. Masaya also presented 1982-83 research at the BIC Meetings in Minneapolis, Minnesota in November, 1983.

3. Guatemalan, Ecuadorian and Cornell scientists will meet and discuss farming systems research and physiological genetic research at INIAP in 1984. This will reinforce CRSP-related research.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States--During this year, Cornell University reinforced its project support. Not only did it maintain its contributions in primary personnel and administrative infrastructure, it also created, under the aegis of Cornell's International Agriculture Program, a multi- disciplinary project advisory committee to offer program guidance and evaluation. The increased participation of international agriculture in program administration has contributed to the strengthening of planning and implementation.

B. Guatemala--Despite difficulties in establishing CRSP funding procedures, ICTA admirably carried out its primary personnel and technical support to the project activities. Considerable resources were devoted to implementation and administration, despite rather severe economic restraints. It is clear that ICTA's commitment to the CRSP activities is firm.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Administrative constraints, involving both Cornell and ICTA, that impeded transfer of funds to ICTA were resolved by September, 1983, putting 1984 project activities on a firm administrative basis. This reflects concerted Cornell action to strengthen the administration by placing the project under the International Agriculture Program and assigning an assistant project coordinator to achieve administrative detail and support program activities.

B. Political instability in Guatemala has raised a question in the past about continued project activity. This year has shown that this is not a definitive constraint on continuity. However, the issue remains of concern.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

A. Current Year

1. Sociology-Agronomy--During Dr. Garrett's work session at ICTA in August, 1983, socio-agronomic goals and activities for 1983-84 were jointly defined. Three contiguous but vertically ordered zones managed by indigenous small bean farmers were identified for socio-agronomic study and initial farming systems research. The contiguous areas have different but also overlapping bean farming practices. Major research areas will include the

analysis of existing secondary data, the description of farming systems, constraints to production, contributions of money and produce to family economics, description of daily consumption of beans, description of family vs. hired vs. exchange labor, cost of production, analysis of community social strata, migration, off-farm labor and salary inputs.

2. Physiological-Genetics of Maturity and Adaptation--Two years of field research at different elevations in Guatemala and also in Colombia under natural 12-hour and 18-hour electric-light extended daylengths have been conducted. The research at CIAT is now complete. Findings include:
   a. Daylength-temperature control over maturity as observed in growth chambers also occurs in the field, but growth chamber responses are exaggerated relative to field responses.
   b. There is an optimum temperature for flowering which in the tropics gives the fewest days expressed by a cv at any altitude and occurs at 800 to 1000 meters (23 to 25°C) for most bean cvs.
   c. Below the optimum temperature (or above 1000 meters) a raise of temperature (lowering of elevation) will modulate earlier flowering and bean maturity, whereas, above it (or at lower elevations) a raise of temperature (lowering of elevation) will modulate later flowering and maturity.
   d. The plant biology giving these temperature responses divides the world's bean production into areas where adaptation is due to below optimum and above optimum temperatures for flowering in interaction with short, moderate and long daylengths.
   e. For 75% of tropical beans, i.e., beans in the tropical highlands, environmental control over maturity is by the below optimum temperature because the low temperatures plus short day virtually eliminate any daylength control.
   f. The high temperature of lowland tropical areas results in Q10 amplification of even the smallest daylength modulated delay of flowering. Therefore, bean production in the tropical lowlands is controlled by the very same photoperiod-temperature modulated days to flowering that controls maturity and adaptation in temperate zones. The only difference is that it is the above optimum temperature for flowering that predominantly controls this delay in node to flower in the lowland tropics, while delay is predominantly by the long daylength in the temperate zones.

X. BASELINE DATA

This data will be generated by the socio-agronomic studies. Relative to physiological-genetics of maturity, the baseline until now has been:

A. Assumption that short days of the tropics prevent all photoperiod modulation of maturity.

B. Lack of knowledge about the optimum temperature for flowering and its gene-directed minimal days to flowering.

C. Lack of knowledge about the physiologically-genetically differentiated above and below optimum temperature effects on time of flowering.

D. Lack of knowledge of how (but not that) temperature influences the photoperiod modulation of maturity.

E. General lack of the concept that a few genes with multiple alleles provide a wide range of potential for quantitatively different levels of change in days to flower and maturity in response to the very same small. medium or large changes of daylength and/or temperature. Recognition continues that it is strongly the specific maturity and consequent adaptation that minimizes or maximizes a cv's yield at each specific location.

XI. FUTURE PLANS

A. Proposed Changes

1. Project Objectives--None.
2. Personnel Changes--Addition of an anthropologist and an agricultural economist to the ICTA staff in 1984 will enable the project to meet its socio-agronomic objectives.
3. Relocation--None.
4. Project Strategies--Socio-agronomic activities will begin. Maturity and adaptation studies will move beyond continuing acquisition of biological knowledge to its application in screening germ plasm plus selection within segregating progenies for specific adaptations to lowland, moderate elevation and highland tropical plus temperate environments. Selection will begin for new genetic recombinants with superior maturities, adaptations and yield for each of the four world zones.

B. Proposed Plan of Work for FY 84

1. Bean germ plasm of importance to Guatemala, plus cvs of varied origins and adaptations, will be evaluated for the three responses to temperature (elevation) in standard cv yield trials. Adaptation to the different year temperatures of highland, lowland and moderate elevation tropics will be quantified. A few lines having these different adaptations plus favorable horticultural characteristics were crossed during June-December, 1983. F_1's of lowland bushes will be grown January-April, 1984 to obtain F_2 seed. The F_2 will be observed and selected during May-August, 1984. Selections will be made for adaptation to the above optimum, optimum and below optimum temperature response

(elevation). Inheritance of the different responses and adaptations will be determined. Only one generation of climbing beans can be grown per year, so F_2 seed will be produced during March-December, 1984.

2. The CRSP-hired anthropologist and agricultural economist will concentrate on acquiring an understanding of the thinking, concerns, problems, aspirations and goals of small farmers and families who grow beans in three different farming systems in the Chimaltenango highlands. This social science approach will complement current on-farm agronomic research by the Chimaltenango Technology Testing Group and the current agricultural economic research by the Socio-Economic Group. An ICTA agronomist will give full-time leadership to bean-related on-farm research of the Chimaltenango Technology Testing Group. On-farm research in 1984 will relate primarily to cv evaluation. This socio-economic-agronomic research will identify researchable constraints.

Improvement of Bean Production in Honduras through Breeding for Multiple Disease Resistance

I. PROJECT ROSTER

A. US Lead Institution: University of Puerto Rico (UPR), Mayagüez

Principal Investigator:	Dr. Julio López-Rosa, College of Agricultural Sciences, UPR
Co-Principal Investigator:	Dr. George F. Freytag, USDA, MITA, UPR
	Dr. James S. Beaver, Department of Agronomy, UPR
Research Assistant:	Lic. Mildred Zapata-Serrano, UPR
	Lic. Rodrigo Echávez-Badel, UPR
Technician:	Ing. Hirám Vélez-Martínez, UPR

B. Honduras Counterpart Institution: Escuela Agrícola Panamericana (EAP)

Principal Investigators:	Dr. Pablo E. Paz, EAP
	Dr. Carlos Pineda (appointed interim PI on January, 1983), EAP
Co-Principal Investigator:	Dr. Jacobo Caceres, EAP
Technicians:	Ing. Pablo Rucks, EAP
	Ing. Luis del Río, EAP
	Mr. Luis A. Martínez, EAP

II. PROJECT OBJECTIVES

A. Produce a MDR bean germ plasm base in order to minimize losses due to diseases and thus provide cropping security over time in Honduras.

B. Preserve or improve the agronomic characteristics, yield and quality of the preferred Honduran cvs to assure economic and efficient production of a crop that will meet the acceptance and fulfill the nutritional requirements of the population.

III. CHANGES IN OBJECTIVES

Although the project has faced difficulties (delayed formalization of agreements and implementation, and resignation of the Honduran PI) no changes in objectives have been considered necessary.

IV. RESEARCH OUTPUTS

A. Available for Immediate Use

1. Black seeded line B-190, which has performed well in the introduction trials in Honduras, has the potential to become a commercial cv for the export market.

2. Breeding lines L-226-10, L-227-1, 3M-150, 3M-152 and 4M-99, which have shown good yield potential and high levels of MDR, were made available through official releases to other breeding programs for use as parents in crossing schemes.
3. Baseline data collected in Honduras are available to help assess the impact of the project on bean production in the country.

B. Available for Use within 1-2 Years
1. Erect black and white seeded lines resistant to BcMV, rust and anthracnose.
2. Article on the incidence of bean diseases in Honduras.
3. Articles reporting practical applications of bacterial blight (*Xanthomonas* spp.) research.

V. TRAINING OUTPUTS

A. United States
1. Degree Training--Ing. Hirám Vélez-Martínez made significant progress toward completion of the M.S. degree in crop protection at UPR. This is part-time study not supported by the CRSP.
2. Non-Degree Training--Lic. Mildred Zapata-Serrano and Ing. Hirám Vélez-Martínez completed short courses in micro computers. Lic. Rodrigo Echávez-Badel completed a summer course in micro computers. These three individuals, together with Dr. López-Rosa, Dr. Freytag and Dr. Beaver, participated in a bean rust workshop in Mayagüez.

B. Honduras
1. Degree Training--Ing. Luis del Río is pursuing a B.S. degree in crop protection at UPR.
2. Non-Degree Training--Ing.. Luis del Río and Ing. Pablo Rucks took part in three weeks of training on bean technology at UPR/TARS.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. UPR
1. Intranational--Contacts and cooperative relationships developed with USDA and several state university bean programs (MSU, UNE, UW, Cornell University, UF and CSU) were maintained and strengthened.
2. International--Collaboration with the CIAT bean program was strengthened. Contacts with PCCMCA were maintained by participation of project personnel in the annual meeting. Germ plasm was exchanged with CNPAF, EMBRAPA, Brazil.

B. Honduras--Collaboration between the project staff and personnel from the Ministry of Natural Resources was widened and strengthened.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States

1. UPR--The project continued to have the support of the UPR authorities. The Chancellor of the Mayagüez Campus, the Dean of Agricultural Sciences, the Associate Dean for Research, the Coordinator of International Programs and the Directors of the Departments of Crop Protection and Agronomy and Soils have all contributed their time to the administration of the project. The personnel, budget and finance offices of the Agricultural Experiment Station also shared with the PI important administrative responsibilities. The financial contribution to the project exceeded the required minimum match of 25%.
2. USDA-ARS/TARS--Part of the time of a bean research geneticist and physical resources (offices, laboratory, greenhouses and vehicles) were contributed.

B. Honduras

1. EAP--The Honduran counterpart institution has provided administrative support and has made facilities (laboratories, library, guest house, land) available. The EAP also made a financial contribution by waiving 10% of the indirect cost charge for the first two years.
2. Ministry of Natural Resources--The Ministry of Natural Resources has made infrastructure available to the project. Project personnel have been given office and storage space, access to Experiment Station land to plant trials and use of official vehicles (project technicians accompanied by personnel from the Ministry).

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

The project was first constrained by a late start resulting from delays in formalization of the agreement and subsequently by the departure of Dr. Pablo Paz, Honduran PI, who resigned from the EAP in December, 1982. The replacement of Dr. Pablo Paz by Dr. Carlos Pineda did not bring the necessary stability as Dr. Pineda was designated on an interim basis. As a solution to this fundamental problem, funds are budgeted (FY 84) to hire a qualified scientist to work full-time. The search for candidates has been initiated in Honduras.

No socio-political constraints have as yet been perceived.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

A. Current Year--Significant progress toward objectives was achieved in the Puerto Rican phase of the project. Progress in Honduras was also satisfactory, despite difficulties mentioned under VIII.

B. Cumulative to Date--Progress toward objectives during the first year and a half has been satisfactory. See IV, Research Outputs.

X. BASELINE DATA

Baseline data were acquired from the El Paraiso and Olancho Departments. The information, although preliminary and incomplete, is relevant to objectives and provides a good reference point for estimating the impact of the project on bean yield stabilization and production in the areas surveyed.

XI. FUTURE PLANS

A. Proposed Changes
1. Objectives--None.
2. Personnel Changes--At UPR, time devoted by Lic. Rodrigo Echávez-Badel was reduced from 50% to 25%. There are plans to hire a full-time technician (B.S. level) to make-up for this deficiency and to support the senior project staff.
3. Relocations--None.
4. Strategies--At this point it appears advisable to defer defining the strategies for FY 84 since this subject will be considered in detail at the review in Honduras the first week of December, 1983.

B. Work Plan for FY 84
1. UPR Research Activities
   a. Obtain new germ plasm from other programs and scientists and screen in laboratory, greenhouse and field for disease resistance.
   b. Crossing block composed of parents with disease resistance and desired seed types.
   c. Evaluation of F_3 and F_4 from genotypes resistant to bacterial blight and rust.
   d. Continuation of RSP development in *Phaseolus coccinus*.
   e. Cooperative work with researchers interested in crosses with *P. acutifolius* as a source of resistance to bacterial blight.
   f. Evaluation of progenies from crosses of MDR *P. coccineus* x advanced lines of *P. vulgaris*.
   g. Continuation of efforts to characterize nature of rust resistance in B-190.
   h. Continuation of work with IVT lines as sources of minor gene protection for the I gene to BCMV.
   i. Advanced line yield trial at the Isabela and Fortuna Substations.
   j. Continuation of testing of selected *P. coccineus* hybrids for resistance to BGMV, BCMV, CpMV and *Xanthomonas*.
   k. Continuation of characterization of BCMV necrotic strain.
   l. Reinoculation of *P. acutifolius* population and reselection for resistance to *Xanthomonas*.
   m. Characterization of *Xanthomonas* isolates from Fortuna.

2. Honduras Research Activities--The proposed work plan is subject to modifications during the early December on-site project review.
   a. Continue multiple location introduction trials for testing the most promising genotypes.
   b. Plant the International Bean Rust Nursery (IBRN) and the International Bean Yield and Adaptation Trial (IBYAT) for red beans from CIAT.
   c. Initiate a crossing program to develop cvs for Honduras using as parentals genotypes with high levels of MDR and cvs of the preferred seed types.

C. Training
   1. Completion, at UPR, of the requirements for the B.S. degree in agriculture and initiation of M.S. program in crop protection by Ing. Luis del Río.
   2. Short course in bean technology at UPR for the technicians, Ing. Pablo Rucks and Ing. Luis A. Martínez.

Improved Biological Utilization and Availability of Dry Beans

I. PROJECT ROSTER

A. US Lead Institution: Washington State University (WSU)

Principal Investigator: Dr. Barry G. Swanson, Department of Food Science and Human Nutrition, WSU

Co-Principal Investigators:
- Dr. George L. Hosfield, Department of Crop and Soil Sciences, MSU
- Dr. Mark A. Uebersax, Department of Food Science and Human Nutrition, MSU
- Dr. Don R. Wood, Department of Agronomy, CSU
- Dr. Paul A. Seib, Department of Grain Science, KSU
- Mr. Lehel Telek, USDA, MITA, UPR
- Dr. George Freytag, USDA, MITA, UPR
- Dr. Julio López-Rosa, College of Agricultural Sciences, UPR

B. Guatemala Counterpart Institution: Instituto de Nutrición de Centroamérica y Panamá (INCAP), Guatemala

Principal Investigator: Dr. Ricardo Bressani, Director of Research, INCAP

Co-Principal Investigators:
- Dr. J. E. Braham, Associate Director, División de Ciencias Agrícolas y de Alimentos (DCAA), INCAP
- Dr L. G. Elias, DCAA, INCAP
- Dr. M. R. Molina, DCAA, INCAP
- Dr. R. Gómez-Breñes, DCAA, INCAP
- Dr. D. Navarrete, DCAA, INCAP
- Mr. C. Argueta, DCAA, INCAP
- Mr. J. M. González, DCAA, INCAP
- Mr. A. García, ICTA

II. PROJECT OBJECTIVES

The primary objective of this research project is to improve the availability, utilization and nutritional quality of dry beans for human consumption in developing countries. Dry bean availability and utilization will be enhanced by coordinating genetic, nutrition and food

technology research. Specific objectives as they relate to dry beans are:

A. Develop an analytical methodology for the characterization of polyphenols (tannins).

B. Determine the role of minerals and storage conditions in the development of the hard-to-cook phenomenon.

C. Determine the effects of polyphenol concentration in the seed coat and the cotyledon on the in vitro digestibility of proteins.

D. Initiate genetic programs to study the variability and mode of inheritance of polyphenol concentration and the hard-to-cook phenomenon.

E. Assess the role of beans in the diets of Guatemalan urban and rural populations.

F. Utilize breeding programs and selected plots to obtain standard bean samples.

G. Carry out collaborative studies of the methods for extracting and determining the quantity of polyphenols.

H. Determine chemical interactions among proteins, carbohydrates and polyphenolic compounds during soaking and cooking.

I. Assess in vivo digestibility in solution with dilute concentrations of polyphenolic compounds using animals and human subjects.

J. Observe chemical and structural changes during various storage conditions.

K. Using assays developed for desirable nutritional characteristics, i.e., trace polyphenolic concentration and limited hard-to-cook phenomenon susceptibility, begin a breeding program with desirable parent materials.

III. CHANGES IN OBJECTIVES

The primary objective has not changed. In the interest of clarifying, coordinating and classifying both proposed research and research progress, project objectives were discussed at a meeting of co-investigators at INCAP in August, 1983. These objectives will be used to report research progress in the Technical Summary and Technical Report. They are:

A. Production
1. Establish relationships between physical, chemical and technological factors and yield performance in common beans.
2. Develop an understanding of the biochemical basis responsible for the chemical, technological and nutritional properties of common beans.
3. Establish nutritional standards for bean breeders.
4. Develop a set of appropriate food technology and food nutritional quality methodologies for screening programs.

B. Handling and Storage
1. Learn about factors (environmental, genetic) responsible for, and the mechanisms leading to, seed color disappearance and hard-to-cook conditions.
2. Develop appropriate storage equipment and conditions to reduce acceptability constraints.

C. Utilization and Consumption
1. Learn the significance and nutritional role of polyphenolic compounds, residual trypsin inhibitors and proteins resistant to digestibility.
2. Establish the need to increase the sulfur amino acid content of dry beans for human nutrition.
3. Establish the physiological effects of eating dry beans.
4. Carry out surveys on the preparation and consumption of dry beans within the family and on native food preparations containing beans.

D. Processing and Food Product Development
1. Study the effects of processes and processing conditions on the nutritional quality of beans.
2. Develop new forms of bean consumption directly or through new products.

IV. RESEARCH OUTPUTS

A. Available for Immediate Use
1. Drying beans with forced hot air was advantageous over sun drying.
2. Steam-heating beans for ten minutes at atmospheric pressure prevented development of the hard-to-cook phenomenon in storage and reduced cooking time after storage.
3. Soaking beans in 15% NaCl solution for five hours and drying in the sun prevented the development of the hard-to-cook phenomenon in storage and reduced cooking time after storage.
4. Steam-heating and soaking in salt water significantly reduced the concentrations of protein and polyphenols in beans.
5. A methodology for the reliable and reproducible estimation of *in vivo* digestibility of common beans was developed.

6. A new method for the determination of procyanidins in tests and cotyledon of dry beans was identified.
7. A sophisticated Instron method was developed to accurately and objectively determine optimum cooking time for beans.
8. A method for preparation of fermented dry bean tempeh was identified.
9. A method for sensitive estimation of biological activity of lectin of kidney beans was developed.
10. Methionine supplementation was shown to enhance protein quality.

B. Available for Use within 1-2 Years
1. A bulletin containing standard analyses to assess bean quality is to be published.
2. Flavonoid profiles of *Phaseolus vulgaris* from tissue culture will demonstrate the relationship between phenotypic traits and genotype of tissue culture.
3. The environment is proposed to be more important than the cv when looking for nutritional and technological characteristics of beans.
4. Methionine supplementation improves the quality of dry bean protein in the diets of adults.

V. TRAINING OUTPUTS

A. United States
1. Degree Training--Ten students, five males and five females, are enrolled in degree programs.
2. Non-Degree Training--None.

B. Guatemala
1. Degree Training--Eleven students, five males and six females, are enrolled in degree programs.
2. Non-Degree Training--Eight INCAP research associates, six males and two females, have received informal training.

C. Other Developing Countries
1. Degree Training--Two males, one from Zaire and another from Colombia, are enrolled in degree programs.
2. Non-Degree Training--One male from Afganistan took part in the BNF Workshop held in Madison, Wisconsin, July 18-20, 1983.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. United States
1. Met with the Nigeria/UG (McWatters) project team.
2. Presented research manuscript at meetings.
3. Contacts established with Western Regional Project W-150.
4. Participated in the workshop to develop a collaborative bean project for East Africa-CRSP/CIAT.

B. INCAP
1. Discussions held with Tanzania/WSU (Silbernagel) project team.
2. Collaborative research conducted with CIAT and ICTA.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States

Salaries	$47,904
Benefits	4,070
Supplies	164
Travel	xx
Indirect	34,830
TOTAL	$86,968

B. INCAP

Salaries	$22,015
Benefits	xx
Supplies	10,035
Travel	100
Indirect	11,253
TOTAL	$43,403

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Invoicing and cost sharing reports from INCAP and subordinate US institutions have been slow in arriving.

B. Difficulty was experienced in organizing objectives for clearer presentation with little constructive critique.

C. Communications and coordination have been impeded by heavy research loads, travel schedules and diverse research interests among investigators.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

Significant progress toward compiling appropriate baseline information on dry bean preparation and acceptibility has occurred. Efforts to coordinate research in the US and Guatemala have been successful and a bulletin containing standard methods for determining the nutritional and cooking quality of beans is being reviewed. Research progress directed to specific objectives is reported below.

A. Production
1. Establish relationships between physical, chemical and technological factors and yield performance in common beans.
   a. Eight strains of beans were selected for genetic analysis of soakability, hard shell development and tannin content. Bean quality traits were influenced more by dominance than by additive variance in genetic studies (MSU).

b. Investigation of environmental and genetic factors of seed yield and protein quality indicated significant differences in yield among cvs, irrigation level and shading treatment. Seed size was affected by cv and irrigation treatment but not by shading. The protein quantity per seed was influenced by cv and irrigation treatment as was protein quality (CSU).

2. Establish a nutritional standard for bean breeders.
   a. A significant correlation was observed between the in vivo and in vitro methods to determine bean protein digestibility. At present, the in vitro method is being studied to obtain sufficient data to permit calculation of in vivo digestibility from in vitro studies (INCAP).
   b. Polyphenols were determined with the Folin-Denis method and by the protein precipitation method of Hagerman-Butler. Polyphenol concentration of beans varied with seed coat color. Total polyphenol losses in cooked bean broths reached 37 to 51% as determined with Folin-Denis and 94-96% as determined with the Hagerman-Butler method (INCAP).
3. Develop a set of appropriate food quality methodologies for screening programs. A bulletin containing standardized and recommended methods for determining the food quality of dry beans is being reviewed (WSU).

B. Handling and Storage
1. Learn about the factors (environmental, genetic) responsible for, and the mechanisms leading to, seed color disappearance and hard-to-cook conditions.
   a. Physical, chemical and technological characteristics of 14 black bean cvs grown in 9 locations and 14 red bean cvs grown in 8 locations demonstrated a significant interaction between cv and location. The environmental effects were more important than genetic make-up for all parameters (INCAP).
   b. An accurate, objective method of determining optimum cooking time of beans was developed using the Instron. Preliminary results indicate the number of broken beans accelerated rapidly after the optimum cooking time was passed (KSU).
2. Develop appropriate storage equipment and conditions to reduce acceptability constraints.
   a. Sun drying beans resulted in significantly greater cooking times than drying beans with forced warm air dryers. Regardless of the drying method, a significant decrease in polyphenol content was observed after drying (INCAP).
   b. Steam heating and soaking beans in NaCl solution prevented the hard-to-cook phenomenon during storage and resulted in a significant decrease in cooking time after storage of three months (INCAP).

c. An accelerated storage method was developed to predict characteristics of the common bean hardness phenomena (INCAP). Beans stored at 41°C at 100% relative humidity (RH) for 14 days required 50% more cooking time than freshly harvested beans (KSU).

C. Utilization and Consumption

1. Learn the significance and nutritional role of polyphenolic compounds, residual trypsin inhibitors and proteins resistant to digestibility.
   a. Improved methods for extraction of polyphenols from embryo and testa of beans have been developed. Development of an absolute standard methodology convenient for the determination of polyphenols in large quantities of bean samples is underway (UPR).
   b. An indigestible protein was observed in the dietary fiber fraction of dry beans. Catechin, residual trypsin inhibitor and non-digestible fibre contribute to the protein digestibility of dry beans. Hemagglutinin activity was completely destroyed by cooking. Cooking reduced tannin significantly (INCAP).
   c. *In vitro* bean protein digestibility and protein quality determined with *Tetrahymena* were inversely related to tannin content. Protein quality correlated well with *in vitro* digestibility. Black bean tannins complexed readily with black bean globulin G_1 to form insoluble precipitates from pH 2.0 to 9.0 (WSU).
   d. Binding of catechin dimers and trimers of globulin proteins appears to be hydrophobic and relatively weak. Binding of polyphenols to denatured proteins is stronger and probably has a greater effect on digestibility (WSU).
   e. A method was developed that allowed sensitive estimation of the biological activity of the lectin of kidney beans. The presence of hemagglutinins after low temperature cooking for long periods may contribute to the low digestibility of legumes (MSU).
2. Establish the need to increase sulfur amino acid content for human nutrition. Methionine supplementation improved the protein quality of cooked black beans consumed by adult human subjects. Protein digestibility of bean broth decreased with methionine supplementation, but methionine concentration appeared to bear little relation to the magnitude of the decrease (INCAP).
3. Carry out surveys on preparation and consumption of dry beans within the family and on native food preparations containing beans. A survey of 108 bean broths indicated a bean broth with approximately 2.6% protein and 14% total solids is most acceptable. Broth from beans cooked for three hours is superior to broth cooked only two and one-half hours. Eating bean broth with corn tortillas slightly increases the protein quality of the mixture. The same supplementary effect was not observed with rice (INCAP).

D. Processing and Food Product Development

1. Study the effects of processes and processing conditions on the nutritional quality of beans. Soaking and cooking times result in an adverse effect on bean protein quality. The most advantageous cooking time is 15 minutes at 121°C and 16 psi, without previous soaking (INCAP).
2. Develop new forms of bean consumption directly or through new products. Tempeh can be prepared by Rhizopus oligosporus fermentation of small red beans. The protein quality of red bean tempeh is enhanced by mixing corn and beans prior to cooking and fermentation (WSU).

X. BASELINE DATA

Baseline data suggest the importance of detailed characterization of cooking practices, nutrient content and acceptance of beans in rural Guatemala:

A. A total of 108 bean broths, as well as cooked and raw beans, were collected from rural Guatemalan homes. Analyses indicated total solids of the bean broths ranged from 4.15 to 17.72% and protein content ranged from 0.7 to 3.6%.

B. A direct relationship existed between total solids and protein; the greater the solids, the greater the protein concentration. Acceptability was observed and it was determined that bean broths containing 2.6% protein and 14% total solids can be considered thick and very acceptable.

C. Bean broth is offered to children four months of age and older. Studies of the nutritive value of bean broth alone, and in combination with cooked cereals or tortillas, indicated combinations were more nutritious.

D. Cooking time of the bean broth was also observed. Broth from beans cooked for three hours was superior to broth cooked for two and one-half hours.

E. An analytical methodology for characterization of polyphenols (tannins) of dry beans has been accomplished. Collaborative laboratory studies and standardization, evaluation and acceptance of methods remain to be accomplished.

XI. FUTURE PLANS

A. Proposed Changes

1. Present adopted objectives to the BOD for review and approval. The objectives are now better organized for clearer presentation and discussion.

2. Better communication and cooperation among investigators will allow better coordination among institutions and investigators to improve and review accumulated data, achieve more efficient use of project resources and progress more rapidly to fulfill proposed objectives.

B. Proposed Plan of Work for FY 84

1. Continued fundamental studies of condensed tannin-protein-carbohydrate chemistry at WSU, UPR and INCAP. Assays of protein quality and digestibility are planned at WSU and INCAP.
2. Studies of the anti-nutritional factors such as lectins and protein as inhibitors are planned at MSU, WSU and INCAP.
3. Collaborative studies on the hard-to-cook phenomenon in beans involving production practices, storage, technology to prevent hard-cooking, structural studies with electron microscopy, textural and chemical assays relating composition to cookability and relationships of breeding to cooking quality will be cooperatively conducted at MSU, KSU, WSU, CSU and INCAP.

Improvement of Drought and Heat Tolerance of Disease Resistant Beans in Semiarid Regions of Kenya

I. PROJECT ROSTER

A. US Lead Institution: University of California (UC), Davis

Principal Investigator:	Dr. Barbara D. Webster, Department of Agronomy and Range Science, UC, Davis
Co-Principal Investigator:	Dr. J. Giles Waines, Department of Botany and Plant Science, UC, Riverside
Research Consultants:	Dr. Ken W. Foster, Department of Agronomy and Range Science, UC, Davis
	Dr. Carl L. Tucker, Department of Agronomy and Range Science, UC, Davis
	Dr. Anthony E. Hall, Department of Botany and Plant Science, UC, Riverside

B. Kenya Counterpart Institution: University of Nairobi, Kenya

Principal Investigator:	Dr. Daniel Mukunya, Department of Crop Science, University of Nairobi
Researchers:	Dr. Chris Coulson, Department of Crop Science, University of Nairobi
	Dr. Francis Itulya, Department of Crop Science, University of Nairobi
	Dr. E. Gathuru, Department of Crop Science, University of Nairobi

II. PROJECT OBJECTIVES

A. Establish collaborative relationships between Kenyan scientists at the University of Nairobi and at other locations and US scientists at UC, Davis and Riverside.

B. Carry out a pilot project on the effects of environmental stress on flower and pod abscission and yield in California.

C. Develop screening techniques for characteristics that improve drought and heat adaptation of beans at UC, Davis.

D. Initiate a bean/tepary breeding program for improving yield potential of beans at UC, Riverside.

E. Introduce and exchange germ plasm between the US and Kenya.

F. Identify Kenyan student(s) and/or technicians for training in the US.

III. CHANGES IN OBJECTIVES--None

IV. RESEARCH OUTPUTS

A. Available for Immediate Use
1. Techniques for establishing bean x tepary plants.
2. Cvs with morphological characteristics related to drought and heat tolerance.
3. Data on growth parameters related to yield and abscission.

B. Available for Use within 1-2 Years
1. Bean x tepary plants with drought (and perhaps heat tolerance).
2. Bean cvs with drought and heat tolerance and some disease resistance.
3. Necessary socio-economic data on Kenyan subsistence farmers.

V. TRAINING OUTPUTS

A. United States
1. Degree Training--One male is enrolled in a Ph.D. program.
2. Non-Degree Training--Two females received training.

B. Kenya
1. Degree Training--One male and one female are enrolled in degree programs.
2. Non-Degree Training--The male enrolled in the degree program attended the BNF Workshop held in Madison, Wisconsin, July 18-20, 1983.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

USAID mission, Kenya; USAID/Kenya Agricultural Research Institute; Kenya Ministry of Agriculture; CIAT; Tanzania/WSU (Silbernagel) and Senegal/UC, Riverside (Hall) projects; Small Ruminant CRSP, Kabete.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States
Departments of Agronomy (UC, Davis) and Botany and Plant Science (UC, Riverside).
1. Administrative assistance in accounting.
2. Time and partial salaries of US PIs, as well as those of technicians and graduate students.
3. Laboratory, field and storage facilities.
4. Greenhouse and growth chamber facilities.
5. Secretarial assistance.
6. Laboratory and field equipment.

B. Kenya
1. Time and salaries of PI and cooperators.
2. Secretarial assistance.
3. Greenhouse and storage facilities.

4. Transportation.
5. Field sites.
6. Laboratory space.
7. Partial support of assistants and graduate students.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. United States

1. Delays in approvals of equipment for record keeping and analysis.
2. Extensive reporting, paperwork and filing.
3. Changes in procedures and delays in approval for purchase of field and laboratory instrumentation.
4. Lack of meetings among Bean/Cowpea CRSP PIs.
5. Difficulty in coordinating details of budget, field work and related activities for all participants (in US and Kenya).
6. Budget complications.
7. Changing personnel (graduate students and technicians) and need for extensive initial training.
8. Complications related to the closure of the University of Nairobi (e.g., obtaining timely records of expenditures and budget projections).

B. Kenya

1. Delays in approvals for purchase of equipment for field studies of drought and heat tolerance.
2. Lack of growth chambers and adequate greenhouse facilities.
3. Lack of a tractor and irrigation equipment.
4. Limited transport availability.
5. Red tape, paperwork, budgetary complications, etc.
6. Difficulties in identifying students qualified for admission at UC, Davis or Riverside.
7. Closure of the University of Nairobi for one year (August, 1982-October, 1983) and attendant difficulties.
8. Difficulty in locating field sites for extensive testing over a long period.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

A. Current Year

1. Screening trials in Kenya identified eleven drought and heat tolerant cvs, some of which showed disease resistance.
2. Sprinkler trials at Davis identified drought and heat tolerant bean and tepary cvs and some morphological characteristics (epicuticular waxes, stomatal characteristics, leaf hairs) related to drought and heat tolerance.
3. Bean x tepary plants were field-tested at Riverside.
4. Short-term field training was held at Davis for a Kenyan collaborator.
5. Fieldwork in Kenya was carried out by US PIs.

B. Cumulative
1. Massive screening trials were conducted in Kenya and at UC, Davis and Riverside to identify disease resistance and drought and heat tolerance in bean cvs from seed obtained from CIAT, Tanzania, WSU, Kenya and Arizona.
2. Sprinkler trials were carried out at Kiboko (Kenya) and Davis to identify growth parameters for measurement of abscission and yield.
3. Bean x tepary embryo culture techniques were developed.
4. Three Kenyans commenced studies in the US.
5. Exchange of germ plasm took place between Kenya and the US.
6. A Kenyan was identified to undertake socio-economic studies of small landholders.

X. BASELINE DATA

A. A literature search was begun and a library was established for records pertinent to activities related to the growth, harvest, cooking and storage of beans.

B. Some information was obtained from a graduate student research project on bean storage, from Food and Agriculture Organization data and from the WID organization reports.

C. Progress was limited by lack of trained personnel and an inefficient system for record keeping (equipment request pending).

XI. FUTURE PLANS

A. Proposed Changes
1. Objectives--Not all of these are actually "changes"; they would be better defined as "expansions" in the directions of the project in keeping with the long-term goal.
   a. Collect quantitative data on temperature, humidity, soil characteristics and rainfall at each of the project sites in Kenya in order to describe more accurately the nature of the drought/heat tolerant bean.
   b. Develop a thorough and accurate disease assessment procedure for beans at each project site in Kenya in order to evaluate the potential for MDR.
   c. Analyze the growth patterns of beans and teparies and the resultant crosses at Davis and Riverside.
   d. Assess nitrogen fixing capacity, dry matter accumulation and source/sink relationships in relation to abscission and yield in promising cvs and field test bean/tepary progeny in California and Kenya--all of which are designed to provide a more accurate portrayal of the plant-environment interaction.
2. Personnel Changes--None anticipated among the PIs and collaborators. One cooperator, Dr. Ian Stewart, will be unavailable in 1984.

3. Relocation--The Kenyan PI, Dr. Mukunya, will relocate for part of 1984 to Riverside and Davis.

B. Proposed Plans for FY 84

1. United States
   a. Assess patterns of growth and development and nitrogen fixation in field trials of beans and teparies showing drought/heat tolerance at Davis.
   b. Field test bean x tepary lines at appropriate locations in California.
   c. Increase seed of promising cvs.
   d. Exchange germ plasm of the most promising cvs.
   e. Develop a disease assessment program with the visiting Kenyan PI.
   f. Identify further physiological and morphological parameters related to drought and heat tolerance.
2. Kenya
   a. Commence trials of eleven previously identified drought and heat tolerant cvs.
   b. Field test tepary lines at selected semiarid field locations.
   c. Upgrade the disease resistance assessment program.
   d. With the receipt of proper equipment, begin to quantify the soil and environmental parameters at each field location.

Genetic, Agronomic and Socio-Cultural Analysis of Diversity among Bean Land-Races in Malawi

I. PROJECT ROSTER

A. US Lead Institution: Michigan State University (MSU)

Principal Investigator:	Dr. M. Wayne Adams, Department of Crop and Soil Sciences, MSU
Co-Principal Investigator:	Dr. P. W. Barnes-McConnell, Bean/Cowpea CRSP, MSU

B. Malawi Counterpart Institution: Bunda College of Agriculture

Principal Investigator:	Dr. O. T. Edje, Department of Crop Production, Bunda College
US Research Associate:	Dr. Eric Ayeh, Department of Crop Production, Bunda College
US Research Assistant:	Mr. Greg Martin, Department of Crop Production, Bunda College

II. PROJECT OBJECTIVES

A. Discover the genetic, agronomic and socio-cultural forces which account for the persistent pattern of bean land-races* diversity in Malawi.

B. Generate from the findings a set of procedural guidelines applicable to Malawi and all other regions where the issue of replacement of traditional land-races by improved cvs currently or potentially exists.

C. In those guidelines bring out the integral role of women in variety evaluations, production, utilization and acceptance.

D. Provide educational and training opportunities for Malawian scientists.

III. CHANGES IN OBJECTIVES--None

IV. RESEARCH OUTPUTS

Socio-cultural research methodology was developed and tested in a field pilot study. See section IX, below.

*The term "land-races" is used in a provisional sense until such time a clearer understanding of their genetic structure is gained.

V. TRAINING OUTPUTS

A. United States
1. Degree Training--Mr. Greg Martin, M.S. candidate at MSU, spent one year working with the team at Bunda College conducting research for his thesis. He returned to MSU in November, 1983 to summarize the data and write the thesis. Ms. Susan Morss commenced doctoral work in September, 1983 supported by an assistantship in Crop and Soil Sciences. Next year she will transfer to the project as her work deals with project research objectives and materials.
2. Non-Degree Training--None.

B. Malawi
1. Degree Training--Mr. James Bokosi and Mr Henry Mloza-Banda from Bunda College arrived at MSU in September, 1983 to commence academic studies toward M.S. degrees.
2. Non-Degree Training--None.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. United States--Seed from the Malawian collections will be provided to Mr. Paul Gepts of the UW to supplement work on protein polymorphism in relation to postulated origins of common beans.

B. Malawi--Bunda College enjoys significant cooperation from the Malawi Ministry of Agriculture and Ministry of Finance in this project. In addition, Dr. David Greenberg, a former member of the Malawi team now working in Zambia, has expressed an interest in including a Zambian student in the program activity.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States--Resources consist of land for experimental plantings, technician time, seed house and machinery, equipment facilities and time of the PI (a great deal of which has been devoted to student-related issues but also to administering the project and to the actual research process).

B. Malawi--Land, labor, use of facilities (such as buildings, laboratories, water for irrigation), time of the Malawi PI (including administrative time for arranging in-country travel of US personnel and bookkeeping time), institutional administrative support and support from extension agents in the field have all been contributed.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

The project has had excellent cooperation from the USAID Mission-Malawi and the Government of Malawi. Country clearance problems for US investigators now appear to be resolved. An additional constraint has been the drought in the south of the country which prevented getting seed collections from that zone in 1982-83.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

A. Current Year

1. Diversity Census
   a. Objective--Secure baseline data on the proportion of various seed types appearing in farmers' fields in Malawi.
   b. Procedure--Random sampling was carried out among single plants (1 pod/plant) or bulk seed samples from each of 5 farms in each of 13 bean growing areas of the country, comprising a total of 65 farms and an average of 1004 seeds per sampled farm site. Seeds of each sample were coded for color, color patterning, size and shape; and frequencies were calculated.
   c. Results--In seed color, 72.2% were of a single color, however, there were 23 different colors (including color blends) represented. Interestingly, the solid color black, so frequent in Central and South American beans, was represented by less than 1% of the single-colored seeds. White, on the other hand, conspicuously absent in much of Central and South American varieties, was found in 22% of the Malawian beans that were mono-colored. Red was the most abundant single color followed by white, yellow, purple and brown. Variegated color patterns were recorded in 22.5% of all beans scored; there were 62 different color combinations observed. All locations or sites showed the presence of mono-colored and variegated seeds. In addition, a color-banded or "zebra" type occurred in 5.3% of the seeds and these consisted of 27 different color combinations.
2. Frequency of Heterozygosity
   a. Objective--Assess the frequency of heterozygosity in samples of the Malawian gene-pool.
   b. Procedure--Randomly selected pods from individual plants, consisting of a total of 533 progenies, were taken from 19 farms in the Northern Zone. These single-plant progenies were grown out and scored at harvest for segregation.
   c. Results--This test was only planted in August, 1983 and final results are not available at this writing (November). However, it is already clear that some progenies are segregating, indicating parental heterozygosity. The number of new seed color-pattern-size-shape combinations which may arise from a single outcross can be astonishingly high. For

example, one line (C110-24) descended from a single three-colored mottled bean in collection no. 110 made in 1982, produced in the first selfed generation 33 unique seed types. In the next generation, from just 6 seeds from each of 11 progenies, there arose 48 new seed types! Thus from one original seed collected in a farmer's field in 1982, over 80 unique seed types have emerged. Had larger populations been grown, probably an even larger number of types would have been found. This example demonstrates the power of a single outcross in generating genetic variability.

3. Heterozygote Superiority--Some of the diversity could be explained if hybrids produced from outcrossing tended to be more vigorous, hence more competitive, and therefore to leave more segregating progeny than non-outcrossed lines.
   a. Objective--Compare hybrids and parents for ability to leave viable progeny in a competitive environment.
   b. Procedure--Test crosses between major "standard-parental" seed types were made in the greenhouse and a plentiful supply of hybrid seed was obtained. The hybrid seeds will be planted along with parental seed and seed of other specially selected non-hybrid stocks under typical farm conditions. Fecundity of all entries will be measured in the F_1 and F_2 generations.
   c. Results--Because of the need to plant this experiment in the main growing season, October-January, the planting has just been made. No data will be forthcoming until 1984.
4. Yield and Yield Stability Experiment--Greater yield stability of mixture over pure monotypic varieties may be a principal reason for farmers preferring and maintaining the genetically complex mixtures.
   a. Objective--Compare complex mixtures with monotypic varieties for yield and yield stability.
   b. Procedure--For this experiment, seed of individual plants of the selected mixtures has to be increased separately and then recomposited to obtain sufficient quantities for the necessary locations and replications. There are 30 entries to be tested, consisting of the following:
      (1) Eighteen lines (homogeneous-monotypic entities), varying in growth habit from CIAT Type I to IV and in region of primary adaptation.
      (2) Nine mixtures, varying from 2 components to 40 components in diversity.
      (3) One F_2 population.
      (4) Two standard varieties, one introduced and one local.

      These 30 entries will be grown in 4 locations for 4 growing seasons, making a total of 16 environment-seasons. Local custom, cropping system and planting density will be used. Environmental and agronomic (plant) characteristics will be measured.

c. Results--The first plantings were made in October, 1983. First data are to become available in 1984.

5. Percent Outcrossing Estimation--Although preliminary and indirect evidence for outcrossing exists, some more quantitative estimation is needed.
   a. Objective--Determine an average value for the extent of natural crossing in beans in Malawi and gain an idea as to how variable this may be.
   b. Procedure--Pure lines differing in flower color (white vs purple) and/or hypocotyl color (green vs colored) were planted in alternate rows, or alternately within the same row, in isolation from other beans and allowed to flower and set seed. Seven such plantings in different locations were made. The contrasting types were harvested separately and seed of the recessive types was planted for scoring of frequency of dominant markers in seedlings and/or flowering plants (hypocotyl color, flower color, vine-bush growth habit).
   c. Results--Some 20,000 plants from the 7 sites have now been scored. The estimate of percent outcrossing, uncorrected for differential flower production and non-overlap of flowering period, ranged from 0 to 2.25%. This is sufficient to introduce a continued low level of heterozygosity into farmers' fields, from which segregants and recombinations may flow, possibly in high enough frequency, given initially contrasting parental stocks and some heterozygote superiority, to account for a significant amount of genetic diversity within the Malawian "land-races."

6. Multi-Variate Estimation of Variation in and among Malawian Bean Land-Races
   a. Objective--Estimate average genetic distances within and between land-races of beans in Malawi.
   b. Procedure--Genetic distances will be estimated by a multivariate statistical procedure known as Principal Components Distance Analysis. Four hundred entries, in three replications, have been laid out in a randomized complete block design under furrow-irrigation at Bunda College. A "plot" consists of six plants derived from one randomly selected plant from each of fifteen farm sites in the Northern Zone. Twenty-five such "plots," tracing to twenty-five randomly selected plants at each of the fifteen sites, comprise the basic experimental units. To these have been added twenty-five "exotic" lines: four cvs from Michigan, six lines from Kenya, three from Colombia, six from elsewhere in Malawi and six from Brazil through CIAT. Some twenty-eight plant and seed traits are being scored.
   c. Results--None available in summary form at this time (November, 1983) on the plant materials. However, site data include rainfall and altitude--but, unfortunately, not temperature--and several soil characteristics which manifest variation in texture, pH, N, P, K, Ca, Mg, Zn, Mn and organic

matter. In addition to seed variability, some collections manifest variability in physiological and phenological parameters as well. For example, in collection C-14, among 36 seed types planted, days to flowering ranged from 35 to 54, flowering duration 17 to 60 days and duration of pod-filling from 19 to 54 days.

7. Socio-Cultural Component--A major objective of this work is to determine how socio-cultural factors affect variability in the Malawian gene pool and what socio-cultural factors contribute to the acceptability of particular cvs. The work in 1982-83 consisted of a pilot study from which preliminary findings are reported and which is used as a baseline to launch more intensive investigations. The report is divided into six sub-sections:
   a. Demographics--The subjects of this study were 25 families in the Northern Zone selected from among those identified during an earlier germ plasm collection trip. They were selected on the basis of their proximity to one another in identified regional clusters to facilitate the work of the teams of enumerators travelling throughout the Northern Zone. The families consisted of 168 people, 82 males and 86 females, of which 45 were male children and 45 female children. The families were classified from "richest" to "poorest" based upon family resources; one-third falling in each of the resource categories--least-limited, average-limited and most-limited.
   b. Production--Bean crops per year ranged from 1 to 3, with 80% having 2 crops per year. Most families were growing mixtures varying from 5 or fewer seed types to more than 15 different seed types. One-fourth of the families did not obtain sufficient beans from the previous harvest to provide for the family until the next crop was in. In 1982, the major constraint in this region was reported to have been weather. The most productive seed type was reported to be the large red kidney. It was noted that the large red bean would usually be productive even in difficult times. Families indicated a preference for this type although they named a total of 32 additional types they grew at the same time. Bean production in Malawi is a family enterprise involving adult males and females as well as children, but the major responsibility falls on the shoulders of the women. Time and energy requirements in doing production-related chores are seen by women as major constraints to increasing their production through farming more land, growing more crops per year or more intensive management (weeding, fertilizing). These factors may also play a role in the selection of bean types to be grown (e.g., easy pulling, easy shelling).
   c. Economics--Farm families both sell beans and buy beans, more families selling than buying. The data reported that bean production makes limited financial demand on family

resources. This will be important in the context of introducing new varieties and practices into the current system.

d. Storage--Families in this study reported an average of approximately 20 lbs. of beans lost in the field and in post-harvest handling. Field losses were attributed to rotting because of rains or morning dew. Pod-shattering was also a serious cause of loss. Families reported using chemicals or ash to protect seeds from insects in storage. The sugar-bean was reported to be most susceptible to insect damage, while those that become hard in storage were the small round whites and the Nyauzembe--the round green bean.

e. Preparation--Most of the bean dishes are variations on boiled beans. Sugar beans require the longest cooking time, with cooking temperatures taken which ranged from 166°F to 200°F at an average altitude of 4753 feet. The Saaba--large red kidney--were reported to keep the best for one to two days after cooking without becoming sour whereas the small round whites do not keep at all well.

f. Consumption and Health--Families that time of year (August-September: nearing the end of the dry season and just before the onset of the major rainy season) eat beans three times a week, most often as mixed beans. The favorite beans for eating were the Nyauzembe, the Saaba and the sugar bean. Reasons given for this preference were "good flavor" and "cooks fast." The preference for red beans, the most popular, was related to the fact that when cooked the red bean made a thick, rich, reddish-brown gravy that was attractive in appearance when used as a relish with maize "nzima" (a kind of mush) and flavorful to taste. Saaba and sugar beans were the beans most often given to children. Children began to eat beans at about one year of age; 24% of the families reported various digestive problems when the children first began eating beans.

B. Cumulative to Date

1. A total of 113 bean seed collections from farms and markets in the Northern Zone were obtained in March, 1982. These collections ranged from monotypic to highly genetically variable, with diversity marked both between and, especially, within collections. In a small planting made at MSU in summer, 1982, factual evidence was found for heterozygosity in some collections.
2. In Malawi, in a two and one-half month period, July-September, 1982, the socio-cultural teams were trained using tested research instruments and assigned to farm-village sites in the Northern Zone to begin the collection of data concerning the growing, processing, storage, cooking and eating of beans.

3. From several standpoints one gets the impression that particular kinds of beans (Saabas, sugar beans, Nyauzembes, etc.), not mixtures, are preferred. Many families maintain two or more of these particular kinds. When planted in adjacent fields, natural crosses will occur between them, resulting in the development of "hybrid" types within the initially homogeneous stocks. Unless these "hybrid" types are continually removed by hand sorting, the homogeneous character of the basic stock will be lost and, in time, a complex mixture will replace it. This scenario may be the basis of origin of the diversity seen in so many instances in Malawi. Its importance for a bean improvement program is suggested.

X. BASELINE DATA

The baseline data obtained in this project come primarily through the socio-cultural component, see section IX, 7. It included, at the pilot study level, a substantial body of information about farm families and their activities in the home and on the farm which have direct relevance to the primary objectives. The data provide a basis for thinking more comprehensively about the reasons for genetic diversity in beans and particularly for answering the questions on factors accounting for acceptance by farmers of new technology, including new bean varieties.

XI. FUTURE PLANS

A. Proposed Changes--None

B. Proposed Plan of Work for FY 84

1. United States
   a. Identify by electrophoretic methods the banding patterns in several standard Malawian types and do the mendelian genetics for several of the systems. This will be the responsibility of Ms. Susan Morss, Ph.D. student and it will provide the basis for studying gene frequency changes in the mixed populations now being grown at five locations in four seasons (two years) in Malawi.
   b. Use the techniques to measure genetic distances within and between "land-races" and compare those estimates with the principal components distance measures obtained by Mr. Martin in Malawi.
2. Malawi
   a. Carry out experiments already underway that relate to stability of yield of mixtures as compared with pure lines. This will require five locations over four seasons, but it is a major responsibility with great implications for bean improvement strategies in Malawi.

b. Use those populations as they change over locations and time to assess gene frequency shifts in the mixtures to answer the question regarding the genetic dynamics of a mixed population. This study will require marker genes which will be identified.
c. Complete the Principal Components Distance experiment now underway at Bunda College.
d. Measure levels of advantage in yield of hybrid beans as compared with pure lines. This has to be done under farm conditions at several locations and hybrids for this study are currently being developed.
e. Carry out more extensive socio-cultural studies in the Northern Zone using the results of the 1982 pilot study to guide the future work, both in design and in content. Identified researchers will be stationed in this zone for a year in order to get more extensive information across full cropping seasons for a larger number of families.

Improving Resistance to Environmental Stress in Beans through Genetic Selection for Carbohydrate Partitioning and Efficiency of Biological Nitrogen Fixation

I. PROJECT ROSTER

A. US Lead Institution: Michigan State University (MSU)

Principal Investigator:	Dr. M. Wayne Adams, Department of Crop and Soil Sciences, MSU
Co-Principal Investigator:	Dr. Peter Graham, Department of Soils, University of Minnesota
Co-Investigator:	Dr. D. Reicosky, Department of Crop an Soil Sciences, MSU
Researcher:	Ms. Catalina Samper, Department of Cro and Soil Sciences, MSU

B. Mexico Lead Institution: Instituto Nacional de Investigaciones Agrícolas (INIA)

Principal Investigator:	Ing. Jorge Acosta, Agronomist, INIA
Co-Investigators:	Ing. Abelardo Nuñez, Physiologist, INI
	Dr. Ronald Fererra, Microbiologist, INIA
Project Coordinator:	Dr. Rogelio Lépiz-Ildefonso, Central Zone Bean Project Coordinator, INIA

II. PROJECT OBJECTIVES

A. Determine patterns of starch and nitrogen accumulation and storage in leaf, petiole, stem and root, and their remobilization in representative architectural types growing under differential conditions of drought and nitrogen stress.

B. Determine the relationship of starch accumulation and remobilization to the rate of seed filling in selected architectural types under a stress and non-stress environment.

C. Determine, in selected genotypes, the effects of photoperiod and temperature changes upon carbohydrate storage-remobilization and upon N_2-fixation.

D. Identify through screening and selection, in populations of Mexican seed types and from other sources, bean genotypes having high and low levels of tolerance to drought and high and low levels of BNF.

E. Determine whether it is feasible to select for both drought resistance and high nitrogen-fixing capability concurrently in the same population and whether genotypes superior in both characteristics simultaneously can be produced.

F. Assess the importance of certain plant growth and phenological characteristics upon the parameters of N_2-fixation in beans.

G. Develop N_2-fixation profiles for drought tolerant selections from CIAT, Mexico and other sources for normal and drought conditions.

H. Evaluate Rhizobium strain performance under glasshouse and field conditions and select strains of Rhizobium efficient in N_2-fixation which are competitive with native strains and persistent over time.

I. Estimate genetic parameters of traits related to or conferring differences in drought resistance and nitrogen fixing ability including heritability, levels of dominance and genetic correlations.

J. Use the information and genetic materials obtained in the experimental phases as sources of improved germ plasm in variety development programs.

K. Involve young scientists, male and female, in the research program and in more structured training and academic studies to prepare them as qualified professionals.

L. Long-term goals are to provide information and genetic materials contributory to developing varieties of greater resistance to drought, with the capacity of fixing nitrogen under the low and uncertain rainfall of the central highlands of Mexico and acceptable to the small growers of the region.

III. CHANGES IN OBJECTIVES--None

IV. RESEARCH OUTPUTS

A. A rain-out shelter was constructed in 1983, making feasible the imposition of drought stress to coincide with particular developmental stages and thus realizing certain kinds of physiological and genetic studies of drought response not otherwise possible in the field.

B. Three, possibly four, bean strains were identified in the Iguala (Mexico) experiment of Ms. Catalina Samper in 1982-83 which show promise as stress-resistant (or tolerant lines). Two of these could have value in the INIA program for drought improvement or directly as improved varieties and in the MSU program as breeding stocks or possibly as improved cvs.

V. TRAINING OUTPUTS

A. United States
Degree and Non-Degree Training--None.

B. Mexico
1. Degree Training--Mr. Francisco Ibarra is in the second year of an M.S. program.
2. Non-Degree Training--Mr. Ibarra participated in the BNF Workshop held in Madison, Wisconsin, July 18-20, 1983. He has also spent time in Mexico in conjunction with project activities.

C. Other Developing Countries
1. Degree Training--Ms. Catalina Samper, a Colombian, has completed experimental work for an M.S. degree. She is now writing the thesis, continuing academic work on the doctorate and commencing doctoral research.
2. Non-Degree Training--Ms. Samper took part in the BNF Workshop held in Madison, Wisconsin, July 18-20, 1983.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

US and Foreign Country/International Institute--Dr. Earl Watt, IITA cowpea breeder stationed at Goiânia, Brazil, has arranged to spend nine months (January, 1984 to October, 1984) on sabbatic leave at MSU, participating in research studies connected with drought stress. Very likely, Dr. Watt will also spend a few weeks during the season in Mexico with Ing. Acosta at Durango.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States--These consist of land, laboratory and other facilities, technician and secretarial time and time of the PI and Co-PI, both in Mexico and in the US.

B. Mexico--Personnel of INIA in Mexico City, Iguala and Guadalajara-Durango have all, in their special situations, contributed time to the project. In addition, in Iguala and Durango, land, laboratories, labor, transportation and equipment have been made available when required.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. The chief problem has been getting equipment bought in the US delivered to collaborators in Mexico. In some cases, items have had to be hand carried by persons travelling to Mexico. This is the only means of assuring delivery.

B. The death of Ms. Samper's father required her to be absent from Iguala during the middle phase of the growing season. Ing. Acosta and others filled in during her absence of about one month, but some data intended to have been obtained could not be gotten. Ing. Acosta and co-workers at Durango in the summer of 1983 attempted to obtain similar data on a duplicate planting of the Iguala test.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

This report consists of brief summaries of objectives, procedures and results of experiments conducted in the US and Mexico in the 1982-83 period.

A. A simple screening test of 92 bean entries was grown under deficient and sufficient levels of soil N, respectively, on a sandy loam soil in Montcalm County, Michigan in 1982. The soil was known to carry Rhizobia bacteria but had been intentionally N-depleted by successive crops of sudangrass in 1980 and 1981. The initial purpose was to search for more efficient N-fixers among the 69 MSU lines in the test which had not been previously screened for BNF. Of the 92 entries, 23 (4 parental genotypes and 19 backcross-inbred derived lines) were obtained from Dr. F. Bliss of UW, the 19 of which had been selected for intermediate to high levels of AR and high yield (except for 2 intermediate and 2 low yielding, under Wisconsin conditions). Leaf chlorosis scores and grain yields were obtained. Preliminary results:

1. The 19 UW selections, showing mild or no chlorosis, yielded among the best at low N but appeared to decline in yield at 40 lbs. N/acre, achieving yields no different than the 5 parental lines. Tentatively, the data suggest that improved BNF resulting from selection led to improved yields at low N, but the improved BNF was not a factor affecting yields at high N. Since there had been no selection practiced at high N, yields reached only the level of the initial parents.
2. The 69 MSU lines displayed, on the average, obvious but mild chlorosis and relatively low yields at low N. Subsets of lines showing little and moderate chlorosis yielded well and poorly, respectively, at low N. It is significant that lines previously unselected for BNF could be found that yielded well at low N, essentially equivalent to lines specially selected for low N. It was not unexpected that the MSU lines, in total or in subsets, should yield well at high N since all had been selected previously for yield at high N.

B. Thirty-six differentially-responding selections from the preceding experiment were chosen for a similar trial in 1983. The site was an abandoned field of sandy loam soil of low N content (about five lbs./acre) in Montcalm County. Plots were 2 rows, 20 ft. long, with 4 replications under high N (90 lbs./acre) and 4 replications with no

added fertilizer N but inoculated at planting with a granular soil inoculant supplied by the NITRAGIN Company of Milwaukee, Wisconsin. High temperatures and prolonged drought characterized this site (weather that was general throughout central Michigan) for six weeks following planting. While growth was slowed, differential nitrogen effects manifested themselves and probably also differential temperature-drought response. Irrigation plus rainfall commencing in late July stimulated flowering and seed set and, by season's close, good to excellent bio-yields and seed yields were obtained with most entries and treatments. Preliminary results:

1. Eight out of eleven UW lines tested both in 1982 and 1983 yielded relatively equivalently in the two years, on low and high N sites, respectively. Lines tracing to Porillo Syntetico were, as a group, top yielders, though individual differences among Porillo-derived lines were noted.
2. There was a rough linear regression of yields at low N (dependent on biological fixation) on yields at high N but with many pronounced departures from regression in the intermediate range of the data. There was no relationship between days from emergence to physiological maturity and yields. Yields dependent upon biological fixation averaged about 100 gms/4 meters less than yields under high mineral N, ranging from 52 to 98% of the latter.
3. The UW lines had, on average, higher nodule scores than the MSU lines (Nodule score = nodule mass, estimated visually). Yields under biological fixation were not correlated with nodule scores even though N was a limiting factor.
4. Plant samples taken at flowering and again at physiological maturity will be used to determine root/shoot ratios and changes of dry weight between the two dates and to provide plant material for N and carbohydrate analysis.
5. The extensive period of dry hot weather that prevailed from mid-June to late-July on this sandy-loam soil appeared to be a strong contributing factor to differential yields in the experiment. Lines common to this test and to the test in Iguala (see next section) performed similarly.

C. The Iguala (Mexico) experiment conducted by Ms. Samper consisted of 22 entries (8 from INIA, 5 from CIAT, 3 from UW and 6 from MSU) previously screened either for drought response or for BNF. The site was on the INIA field station at Iguala, characterized by minimal rainfall during the winter months and moderate to increasingly rising temperatures as the winter growing season advances. Treatments consisted of mineral nitrogen fertilized (+N) versus soil implant inoculation (inoculant supplied by the NITRAGIN Company, Milwaukee, Wisconsin) and furrow-irrigation throughout growth (c) versus water stress (s) imposed by withholding irrigation from flowering onward to maturity. The experiment had numerous facets, most of which cannot be gone into in this brief summary, and some vital ones for which data are still in process of being obtained (carbohydrate

analyses). The principal objective was to explore the relationship between carbohydrate storage in stem and root and its potential remobilization under a moderate drought stress. Preliminary results:

1. The geometric mean of seed yields under non-stress (Y_C) and under stress (Y_S) was used as the best measure of a genotype. On this metric, yields ranged from 2044 to 660 kg/ha. A two-way plot of Y_C against Y_S showed the entries falling along a positive regression line of near unity and appearing also to fall into five clusters of one, eight, seven, five and one entry per cluster, respectively.
2. In addition to economic yield, other data obtained included bio-yield, harvest index and changes in stem and root dry weight of all entries under both stress and non-stress conditions. Space does not permit a full presentation of the findings here. On the salient point, however, it was inferred that the combination of increases in harvest index, coupled with the sharp decline in bio-yield as contrasted with mostly non-significant declines in economic yield for certain lines under drought stress, implies a greater utilization of remobilized dry weight from stems and roots of the stressed plants in seed-filling. There is clear evidence, however, that ability to remobilize under stress does not, of itself, assure high yield. If a line is not inherently high yielding, remobilization will not correct that condition. What is implied is that a yield reduction, occurring as a result of a drought stress during seed-filling, will be buffered.
3. The findings are consistent with the proposition that high yielding lines under a mid-pod filling stress will be relatively efficient remobilizers of stem and root dry weight and that most inefficient remobilizers will be relatively lower yielding under stress. Obviously, these results need extension to a wider array of genotypes and stresses and need to be fortified by carbohydrate analysis.

D. Four field experiments were conducted in Durango in the 1983 season. Final data were not available at the time of this writing. A very brief description of each trial will convey the direction and scope of work undertaken this year.

1. Preliminary Screening of Germ Plasm for Drought Tolerance--A total of 1500 entries, 1000 from the CIAT germ plasm bank and 500 from the INIA bank, were grown in single rows 6 meters long at a site near Durango characterized by irregular and low rainfall. A tester variety, Bayo Madeso, known to be well-adapted to this site was planted every tenth row. The objective of this trial is to identify in a broad cross-section of bean germ plasm any lines that appear to have some tolerance to drought, as represented by the conditions at this location. The selection criteria are plant vigor, freedom from obvious drought stress symptoms and grain yield. It is expected that approximately 60 lines will be selected for further studies.

2. From previous screening trials, 60 lines were planted in 2 replications, with water (by irrigation) and without water (protected by plastic rain-shelter). The 60 lines grown in 1983 included lines from INIA, CIAT and MSU and some lines of the tepary bean, Phaseolus acutifolius, a species renowned for its high temperature and drought resistance. Phenological data, physiological parameters, soil moisture parameters and bio-yield and grain yield will be measured. The objective is to try to identify some characteristics which can be used by breeders to aid in identifying genotypes resistant or tolerant to drought.
3. A trial of ten lines, including a locally well-adapted variety, a tepary and several from the Iguala experiment, was planted under dry conditions for more extensive physiologic studies, including leaf water potential, leaf temperature, leaf gas exchange (porometer) and root extractions. This trial consisted of multiple row plots in four replications. The objective is to continue the search for physiological explanations of differential drought tolerance and provide the breeder-agronomist with valid criteria for use in genetic improvement.
4. The Iguala experiment of Ms. Samper was duplicated completely at Durango except for the elimination of a few genotypes that performed so poorly at Iguala that it was deemed not worthwhile to include them. The test consisted of 15 entries, with mineral N, with inoculation by a composite of local effective strains of Rhizobium phaseoli and with and without water, the latter achieved by use of temporary plastic shelters. Three replications were grown. In addition to phenological and yield data, plant samples were taken for N and carbohydrate analysis of root and stems. Seed filling rates are to be estimated through pod samples taken three times. The objective is to compare results with the Iguala data (Iguala in December-April is a highly contrasting environment to Durango during June-October) and to test under the Durango environment the hypothesis that carbohydrate and/or N storage and remobilization are factors affecting stress tolerance in beans.

E. At the University of Minnesota, Dr. Peter Graham has conducted the following work:
1. Evaluation of Strains of R. Phaseoli for Competitiveness in Nodule Formation--Strains known to be ineffective and effective in N_2-fixation in International Bean Inoculation Trials (IBIT) throughout Latin America or in inoculation trials at CIAT (Graham et al. 1981, 1982), have been evaluated for competitiveness. Strain UMR 1899 (=CIAT 899) proved extremely competitive in these studies, forming a high proportion of nodules even when other strains present outnumbered it 2.5-fold. A suite of strains which differ in competitive ability have been selected and are currently being characterized serologically and by antibiotic resistance patterns. It is intended that these strains will be used to rapidly screen isolates from Mexico and Brazil which have already been selected for high N_2-fixation.

2. Evaluation of Host Cvs for Capacity to Fix N_2 in Symbiosis--A total of 350 cvs selected from the 1981 and 1982 EP-trials and from among varieties common in Mexico and Brazil have been screened in unreplicated trials for ability to fix N_2 symbiosis. Most materials proved unadapted to Minnesota conditions, being late to flower and adversely affected by bacterial blight. A number of lines were selected, however, and will be used, together with drought tolerant materials identified at MSU and in Mexico and obtained from Dr. Bliss' program, in studies of carbohydrate partitioning and N_2-fixation.
3. Evaluation of Small-Seeded Ancestral Lines of P. vulgaris for Nodulation with R. phaseoli--Specificity in nodule formation can be used to overcome competition from rhizobia present in the soil. Small-seeded lines of P. vulgaris could also be employed in test tube assays by the most probable number (MPN) technique, a considerable improvement over existing methods. Because of these opposing possibilities, 35 small-seeded sylvestral lines of P. vulgaris were evaluated for nodulation and N_2-fixation in Leonard jar trials with UMR 1899. All lines were nodulated but nodule mass and plant dry weight accumulation varied appreciably. Further tests will be undertaken to determine whether these and other cvs show selectivity for particular strains.

X. BASELINE DATA

No such data was acquired by the project. In previous years INIA has acquired climatic, agro-ecologic and production systems information.

XI. FUTURE PLANS

A. No major changes in direction are anticipated at this time. The project lists eleven specific objectives. It is not appropriate, even if possible, to work on all of them simultaneously. They must be programmed over several growing seasons. It does appear that as the project moves forward new research ideas may come along which will need to be incorporated. This is likely to be the case when Dr. Watt of IITA arrives in January, 1984 to spend a nine-month leave with the project. He will do both a greenhouse experiment and participate in a field experiment, probably in Mexico, but these plans have not yet been finalized.

B. Proposed Plan of Work for FY 84
   1. United States
      a. Greenhouse experiment
         (1) Provisional title--Estimation of the proportion of stored carbohydrate in root and stem remobilized to seed following a drought stress
         (2) Objective--Obtain a quantitative measure of remobilization of stored starch from root and/or stem tissue, pod and seed during a stress imposed by withholding water.

b. Summer experiment
   (1) Provisional title--A biometrical genetic analysis of tolerance and of major components of tolerance to drought stress in beans
   (2) Objective--Related to project objective I, section II
c. University of Minnesota
   (1) Conduct studies on the partitioning of carbohydrate and nitrogen in relation to BNF in lines selected as high and low producers from the Mexican and MSU experiments of 1982-83.
   (2) Carry out initial studies on rhizobial strain compilation and host plant by strain specificity.

2. INIA
   a. Participate in the generation advancing of some 200 F_3 families selected in 1983 in Michigan (crosses involving N81017, the top yielder in the Iguala experiment) followed by individual and family selection under stress at Iguala or Durango.
   b. Grow backcross and F_3 generations from two crosses (N81017 x Durango 222 and N81017 x N80027) for obtaining data for biometrical genetic analysis as referred to above.
   c. Continue germ plasm screening as in 1983 and studies on physiological, morphological and phenological components conditioning plant responses to drought stress.
   d. Analyze plant samples from 1983 experiments in Iguala and Durango for carbohydrate and nitrogen.

Medical Aspects of Feeding Cowpeas to Children

I. PROJECT ROSTER

A. US Lead Institution: Michigan State University (MSU)

Principal Investigator:	Dr. Pericles Markakis, Department of Food Science and Human Nutrition, MSU
Co-Principal Investigator:	Dr. Wanda Chenoweth, Department of Food Science and Human Nutrition, MSU
Consultants:	Dr. D. Greenbaum, Department of Food Science and Human Nutrition, MSU Dr. H. Sadoff, Department of Food Science and Human Nutrition, MSU

B. Nigeria Counterpart Institutions: University of Jos and University of Ibadan

Principal Investigators:	Dr. D. Drew, Department of Pediatrics, University of Jos Dr. A. Omololu, Department of Human Nutrition, University of Ibadan
Co-Principal Investigators:	Dr. A. M. Hussain, Department of Human Nutrition, University of Ibadan Dr. N. Okere, Faculty of Medicine, University of Jos Dr. I. Akinyele, Department of Human Nutrition, University of Ibadan

II. PROJECT OBJECTIVES

A. Explore a possible relationship between eating cowpeas and gastro-intestinal (GI) problems in young children.

B. Identify the factors present in cowpeas which may cause the problems.

C. Remove these factors from cowpeas so that children may benefit from this otherwise nutritious food.

III. CHANGES IN OBJECTIVES--None

IV. RESEARCH OUTPUTS

A. Two surveys were conducted in Nigeria, one in the Jos area and one around Ibadan, for the purpose of exploring the relationship between cowpea consumption and GI disturbances in young children.

1. According to the Jos survey, 103 out of 798 families interviewed (12.9%) reported GI symptoms in children following ingestion of cowpeas by the children. The most common symptom was diarrhea.

2. Similarly, the Ibadan survey revealed that out of 520 mothers interviewed, 49 (9.4%) reported GI problems in children who were fed cowpeas. Again diarrhea was the most frequent complaint.

B. MSU reported the analysis of six Nigerian cowpea varieties, grown in Georgia, for stachyose and raffinose, two oligosaccharides implicated in the incidence of flatulence in adults.

V. TRAINING OUTPUTS

A. United States
1. Degree Training--None.
2. Non-Degree Training--None.

B. Nigeria
1. Degree Training--Ms. Phillipa Ogun commenced a Ph.D. program in Food Science and Human Nutrition at MSU in March, 1983. She is fully supported by this grant. Her doctoral research will deal with cowpeas and the health of children.
2. Non-Degree Training--A number of young people were trained by the staff of the Universities at Jos and Ibadan for the task of interviewing families in connection with the project.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

This project is a collaborative undertaking between the Universities of Jos and Ibadan, Nigeria, and MSU.

A. Intranational
1. The two aforementioned Nigerian universities cooperate with the University of Nigeria, Nsukka, which is studying appropriate technology for cowpea preservation and processing and the socio-economic impact of this.
2. MSU is in contact with UG, collaborating on a cowpea appropriate technology study.

B. International
1. In September, 1983 representatives of the University of Jos and Ibadan met with their MSU counterparts in London for an annual project review.
2. A similar review between MSU and UG researchers took place in Dublin, Ireland the following week.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

While this project at MSU was initiated under the Bean/Cowpea CRSP, most of the research on cowpeas and their relationship to the health of children will be conducted in Nigeria.

A. The Universities of Jos and Ibadan provide the academic and auxiliary personnel as well as the physical facilities (homes, hospitals, laboratories) where most of the work is performed.

B. The MSU team, in addition to its consulting role, is also engaged in certain chemical and biochemical studies of cowpeas.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. This project experienced significant delays from its inception, chiefly as a result of communication difficulties and personnel changes.

B. Obstacles still exist as approval from Washington, DC for purchasing equipment, especially a vehicle for use by the Ibadan team, is excessively delayed.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

It was only during this past year that the first phase of the projected work was accomplished, i.e., the completion of the diet-illness surveys. The main findings from these surveys are summarized under IV, Research Outputs.

X. BASELINE DATA

The surveys reported above provide some important baseline data.

XI. FUTURE PLANS

The survey findings need additional study. One of the Nigerian teams (Ibadan) plans to extend their survey to 1,000 families before attempting a final interpretation. The next step for both teams will be a verification of the alleged relationship between cowpea consumption and ill-effects in children. Nurses will be sent to homes which registered relevant complaints to observe independently the results of feeding cowpeas to children. Should the verification be confirmed, an effort will then be made to identify the constituents of cowpeas which cause the illness. Oligosaccharides, hemagglutinins, trypsin inhibitors and minerals will be assayed in foods traditionally prepared from cowpeas. If suspicious quantities of potentially toxic compounds are found, efforts will be made to purify these compounds and test them with experimental animals. At the Jos Medical School controlled studies will be conducted to evaluate the absorption of cowpea oligosaccharides in children susceptible to cowpea intolerance by means of the breath hydrogen test. Should the agent(s) causing the GI problems be positively identified, procedures will be sought which will eliminate or neutralize the agent(s) in foods prepared from cowpeas.

Appropriate Technology for Cowpea Preservation and Processing and a Study of its Socio-Economic Impact on Rural Populations in Nigeria

I. PROJECT ROSTER

A. US Lead Institution: University of Georgia (UG)

Principal Investigator: Ms. Kay H. McWatters, Department of Food Science, UG

Researchers:
- Dr. L. R. Beuchat, Department of Food Science, UG
- Dr. M. S. Chhinnan, Department of Food Science, UG
- Dr. R. D. Phillips, Department of Food Science, UG
- Dr. R. E. Worthington, Department of Food Science, UG

B. Nigeria Counterpart Institution: University of Nigeria, Nsukka

Principal Investigator: Dr. P. O. Ngoddy, Department of Food Science and Technology, University of Nigeria, Nsukka

Researchers:
- Dr. Z. A. Obanu, Department of Food Science and Technology, University of Nigeria, Nsukka
- Dr. I. C. Obizoba, Department of Home Science and Nutrition, University of Nigeria, Nsukka
- Dr. V. I. Onuorah, Department of Home Science and Nutrition, University of Nigeria, Nsukka
- Dr. N. D. Onwuka, Department of Food Science and Technology, University of Nigeria, Nsukka
- Dr. G. S. Ayernor, Department of Food Science and Technology, University of Nigeria, Nsukka
- Dr. A. Dike, Head, Department of Sociology/Anthopology, University of Nigeria, Nsukka
- Dr. D. O. Nnanyelugo, Head, Department of Home Science and Nutrition, University of Nigeria, Nsukka

II. PROJECT OBJECTIVES

Second Year

A. Determine cowpea cvs amenable to dry processing.

B. Evaluate the nutritional, sensory, functional and microbiological quality of promising samples of cowpea meals.

C. Initiate twelve-month storage studies of promising samples of cowpea meals.

D. Begin analysis and follow-up study of the survey of socio-cultural and socio-economic factors of cowpea usage.

III. CHANGES IN OBJECTIVES--None

IV. RESEARCH OUTPUTS

A. Project-Specific Publications and Presentations at National/International Meetings:

Baker, E. A., R. D. Phillips and N. L. Canolty. 1983. Protein quality of raw cowpea flour. (Abstr.) 43rd Annual IFT Mtg., New Orleans, LA, June 19-22, p. 190.

Beuchat, L. R. 1983. Mycological quality of cowpeas during long-term storage. (Abstr.) 26th Annual Conference of the Canadian Institute of Food Science and Technology. Ottawa, Ontario, May 29-June 1, p. 50.

Chhinnan, M. S., K. H. McWatters, V. N. M. Rao and R. D. Phillips. 1983. Rheological properties of cowpea paste. Proceedings of the Sixth International Congress of Food Science and Technology. Dublin, Ireland, September 18-23. Vol. 2, p. 132-133.

Hudda, L. B. and M. S. Chhinnan. 1983. A quantitative method to determine the degree of decortication in grain legumes. (Abstr.) 43rd Annual IFT Mtg., New Orleans, LA. June 19-22, p. 205.

McWatters, K. H. 1983. Compositional, physical and sensory characteristics of akara processed from cowpea paste and Nigerian cowpea flour. Cereal Chem. 60:333-336.

Phillips, R. D. and J. G. Adams. 1983. Nutritional and physiological response of rats to diets containing whole, decorticated and decorticated, steamed cowpeas. Nutr. Rep. Int. 27:949-958.

Phillips, R. D. and K. H. McWatters. 1983. Effects of extrusion and drum drying on functional properties of cowpea flour (Abstr.). 43rd Annual IFT Mtg., New Orleans, LA, June 19-22, p. 101-102.

Worthington, R. E. and K. H. McWatters. 1983. Sensory quality of cowpea seeds treated with vegetable oils to prevent insect infestation during storage. Proceedings of the Sixth International Congress of Food Science and Technology. Dublin, Ireland, September 18-23, Vol. 2, p. 209-210.

B. Project-Related Publications and Presentations at National/International Meetings:

Phillips, R. D., E. A. Baker, M. B. Kennedy, M. S. Chhinnan and V. N. M. Rao. 1983. Production, textural and nutritional properties of extruded foods from cowpea meal. Proceedings of the Sixth International Congress of Food Science and Technology. Dublin, Ireland, September 18-23. Vol. 1, p. 122-123.

V. TRAINING OUTPUTS

A. United States

1. Degree Training--Mr. Mark B. Kennedy completed an M.S. degree at UG in December, 1982. His thesis title is: "Extrusion of Cowpeas: Effects of Extruder, Feed Moisture and Barrel Temperature on the Physical Properties of Extruded Cowpea Meal." Mr. Richard G. Falcone completed an M.S. degree at UG in December, 1983. His thesis title is: "Effects of Feed Composition, Feed Moisture and Barrel Temperature on Physical, Rheological and Organoleptic Properties of Extruded Cowpea, Sorghum and Peanut Blends." Both Mr. Kennedy's and Mr. Falcone's work were non-CRSP supported but project-related. Ms. Elizabeth A. Baker received an M.S. degree at UG in December, 1983. Her thesis title is: "Effects of Extrusion and Drum-Drying on the Nutritional Quality of Cowpea Meal as Determined by in vivo and in vitro Assays." Ms. Baker's work was CRSP supported.
2. Non-Degree Training--None.

B. Nigeria

1. Degree Training--None is in progress. However, contacts were made with five Nigerians (three females, two males) with regard to their interest in entering the graduate program in Food Science at the UG and developing a project on cowpea utilization technology. One of the males, Mr. Ifendu Nnanna, has been accepted into the graduate studies program and will begin course work for a Ph.D. degree in January, 1984.
2. Non-Degree Training--None.

C. Other Developing Countries

1. Degree Training--Ms. Laila B. Hudda completed an M.S. degree at UG in December, 1983. The title of her thesis is "Mechanical Dehulling of Cowpeas Using Wet and Dry Methods." Ms. Hudda was supported by the CRSP.
2. Non-Degree Training--None.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

These linkages include personnel associated with:

A. The Nigeria/MSU (Markakis) Bean/Cowpea Project--Dr. P. Markakis, PI, and Dr. Isaac Akinyele, Co-PI.

B. IITA--Dr. S. R. Singh for source of cowpeas and potential graduate students.

C. Food Research Institute, Ghana--Dr. Florence Dovlo for potential involvement in assessment of consumer acceptability of cowpea products developed during project research.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States Institution Contributions Consist of:
1. A PI and four Co-PIs (salaries contributed to meet 25% cost-sharing requirement)
2. Technical and secretarial support
3. Administrative support
4. Laboratory equipment and supplies
5. Pilot plant facilities
6. Training for graduate students

B. Nigerian Institution Contributions Consist of:
1. A PI and seven Co-PIs
2. Technical and secretarial support
3. Administrative support
4. Materials and supplies
5. Milling equipment
6. Undergraduate student training

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. There is not sufficient lead time for the US institution to communicate with and receive responses from the Nigerian institution for contributions to budgets and annual reports.

B. Communication of reports of project activities from the Nigerian institution to the US institution is infrequent.

C. Personnel difficulties have been experienced at the Nigerian institution.

D. The University of Nigeria, Nsukka Users' License which exempted the University from having to pay customs fees on items shipped to Nigeria has expired.

E. A variable speed motor, which is needed to operate an abrasive dehuller, was lost.

F. Storage parameters have been constrained by other storage studies utilizing common facilities.

IX. PROGRESS TOWARD PROJEC OBJECTIVES

A. Mechanical Dehulling of Cowpeas
1. Research conducted at the University of Nigeria, Nsukka has resulted in the development of a pre-treatment process that effectively loosens the seed coat of cowpeas for mechanical dehulling. The process involves adding water to whole seeds to bring the moisture content to 40% on a wet basis, equilibrating the moist seeds at room temperature for three hours to bring

about uniform moisture distribution in the seeds, rapidly drying the seeds in hot air (100-120°C) to reduce the moisture content to 8% (wet basis). Cowpea seeds with loosened seed coats may then be dehulled in an Engelberg rice pearler in one pass. Throughout, capacities in the range of 250-300 kg/hr have been achieved with over 95% efficiency removal of the seed coat. The resulting cowpea splits have a natural and excellent color.

2. Research conducted at the UG in dehulling of cowpeas by wet methods has shown that boiling water soakings result in high dehulling efficiencies. However, the increased energy demand for heating the water and reduced energy requirements for drying the wet-dehulled cowpeas are not known but should be determined. For dehulling by dry methods, a pre-treatment process consisting of soaking followed by heating was found to be effective in improving dehulling efficiency. A three-minute soaking and 120°C heating pre-treatment produced an acceptable dehulled product at very high levels of extraction rates (90%). In a related study, a simple method to determine quantitatively the extent of testa removal in a decortication process was also developed. A dye-staining technique employing the use of 0.25% methylene blue in 70% ethanol produced the best results. Preliminary work has shown that a mathematical relation established between the absorbance values and the degree of decortication for cowpeas not subjected to any pre-treatment may also be applicable to pre-treated cowpeas.

B. Nutritional, Sensory Quality and Functionality Studies

1. Nutritional Quality of Protein in Raw, Extruded, Steamed-Drum Dried and Deep-Fat Fried Cowpea Meal--This study was conducted to assess the effect on protein quality of cowpea meal processed by traditional (e.g., akara-making) and novel (e.g., extrusion) methods. While raw cowpea flour exhibited a relatively high protein quality compared to that of other legumes, processing was able to improve quality further. Overall, steaming-drum drying produced the least improvement while low temperature, low moisture extrusion produced the most improvement.

2. Effect of Particle Size Distribution on Functionality of Cowpea Meal--Cowpea flour is available in West African markets but has not gained widespread acceptance, largely because of its poor functionality, i.e., water absorption and performance in preparation of traditional foods. Poor performance of a commercial cowpea flour obtained from Nigeria and used as an ingredient in akara, a traditional West African dish made from cowpea paste, may have been due to its extremely small particle size. Particle size analysis showed that the flour was considerably finer in particle size than traditional paste. The greatest concentration (68%) of flour particles occurred in the 200-400 mesh range, compared to 64% occurring in the 50-100 mesh range for traditional paste. A Microjet 10 mill equipped with a 1.0 mm screen produced meal with 82% of the particles in the

50-200 mesh range; this particle size distribution was similar to that of traditional paste which had 80% of its particles occurring in the same range. These results indicate that milling conditions presently employed in West Africa for producing fine flours from maize and sorghum are not appropriate for production of cowpea flour to be used in akara preparation. Modification of present milling procedures and/or recommendations for the consumer's use of milled products may be warranted.

3. Effect of Water Level and Hydration Time on Functionality of Cowpea Meal--In addition to particle size distribution, other factors to be considered in optimizing the performance of hydratable cowpea meal/flour are water-solids ratio and hydration time. Results showed that cowpea meal prepared in a Microjet 10 ultracentrifugal mill equipped with 1.0 mm screen (final meal moisture content of 11%) and hydrated by the addition of 60% water produced paste and akara with physical characteristics and sensory attributes much like that of traditionally-made akara.
4. Rheological Properties of Cowpea Paste--Results of studies to characterize the rheological properties of traditionally-made cowpea paste and experimental paste (made from hydrated flour) indicated that both types of paste exhibited similar non-Newtonian flow properties. The water level used to hydrate cowpea flour had a greater effect on apparent viscosity than hydration time.
5. Functional Properties of Raw, Extruded and Steamed-Drum Dried Cowpea Meals--This study was conducted to determine the functional properties of pre-cooked cowpea flours such as might be utilized in traditional or novel foods but with minimal home processing. Results showed that high-shear extrusion cooking under the conditions studied is capable of producing pre-cooked cowpea flours which are similar to but not identical with low shear cooking-drum drying. Slurries of high viscosity but greater pseudoplasticity (higher flow rate at high pump rate) may be produced by extrusion compared to the other process. Extruded flours tend to be more soluble and less capable of binding water than steamed-drum dried ones. Other functional properties were similar.
6. Functionality of Cowpea Starch and Protein in Paste-Type Food Systems--Results obtained on functional properties as related to cowpea flour, cowpea protein isolate and cowpea starch indicate that the starch plays the most important role in swelling and gelling characteristics while the protein tends to modify the texture and gel-strength of the pastes.

C. Cowpea Storage Studies

1. Mycological Quality of Cowpeas During Long-Term Storage--The survival of mycoflora naturally present on cowpeas (*Vigna unguiculata*) as well as *Aspergillus flavus* inoculated on cowpeas and cowpea flour was monitored over a long-term storage period.

The a_w (0.65 and 0.44) did not influence the survival of A. flavus at 4 and 21°C where remarkably high viability was observed after 20 months of storage. At 37°C, loss of viability was greater than at 4 or 21°C; a more rapid reduction in viable conidiospores was noted at a_w 0.66 than at a_w 0.44, regardless of the form of the cowpeas, when storage was at 37°C under atmospheric gas or vacuum. When packaged under an atmosphere of nitrogen, total mycoflora and A. flavus population maintained highest viability. The influence of a_w and temperature on survival of these populations was minimal when cowpeas were stored under a nitrogen atmosphere.

2. Effect of Vegetable Oil Treatments on Resistance to Insect Infestation and Sensory Qualities--Storage studies were initiated with whole seed treated with vegetable oils (palm, peanut, corn). These studies are in progress. Thus far the data indicate that palm oil is most effective in imparting resistance to infestation by cowpea weevil and that this oil also develops less disagreeable odor and flavor during storage of treated seed.
3. Sorption Isotherms for Cowpeas and Cowpea Flour--Sorption isotherm data, essential to studying storage stabilities of food materials, were obtained for whole, undehulled cowpeas, dry and wet dehulled cowpeas, and flour from dry and wet dehulled cowpeas. The process used to prepare cowpeas and cowpea flour of known moisture content must be considered when assessing and predicting mycological quality during short and long-term storage. Wet and dry-dehulled cowpeas yielded higher equilibrium moisture contents than undehulled cowpeas. No significant difference was observed between the sorption curves of dry-dehulled cowpeas and flour. The sorption curve for wet-dehulled cowpeas was lower than that of flour made from it. The total heat of sorption and the net heat of sorption for the materials investigated ranged from 11.78 to 12.10 kcal/mole and 1.21 to 1.54 kal/mole, respectively.
4. Development of Electronic Bean/Cowpea Cookability Tester--A simple and objective method for comparing cooking time of beans stored under different conditions was developed by KSU researchers. The device was modified by UG researchers to monitor electronically the piercing of each cooked seed. The recording of a signal on a strip chart recorder provided an accurate record of the number of seeds cooked versus the cooking time. The prototype model was tested on vegetable-oil-treated cowpeas stored under different environmental conditions for three months. Typical sigmoidal-shaped responses from the cookability tests were obtained. Minor mechanical problems with the device will be corrected during the second phase of development.

D. Survey Activities--A pilot survey of approximately 200 respondents was conducted in Nsukka, Nigeria during August, 1982 to collect socio-cultural and socio-economic data. The survey was directed by Dr. Azuka Dike, Head, Department of Sociology/Anthropology at the

University of Nigeria, Nsukka. The survey instrument was a questionnaire which contained 63 questions pertaining to age, marital status, household size, occupation, education, income, knowledge and frequency of use of cowpeas, cowpea storage methods, cowpea farming and feeding of cowpeas to children. Results of the survey have been tabulated but not summarized and interpreted. A food science/human nutrition-type survey is being conducted in the Nsukka area. It is being directed by Mr. D. O. Nnanyelugo, Head, Department of Home Science and Nutrition at the University of Nigeria, Nsukka.

X. BASELINE DATA

Activities to acquire socio-cultural and socio-economic data were discussed under Section IX, above. Basic information obtained from the pilot survey is on file with the MO.

XI. FUTURE PLANS

A. Project Strategies--These include improvement of Nigerian instrumentation to measure physical properties of cowpea pasting systems, training Nigerian co-investigators in the use of instrumentation and development of regular reporting schedules to improve communication.

B. Proposed Plan of Work for FY 84

1. Processing studies will determine the effects of processing variables (i.e., pre-treatment of cowpea seeds to facilitate decortication) on the milling, functional, sensory and physical-chemical properties of products made from pre-treated, decorticated cowpea seeds. Fine, middling and coarse fractions will be examined for proximate composition, total starch content, amylose/amylopectin content and protein characteristics.
2. Storage studies will involve evaluation of cowpea meal and whole seeds stored up to twelve months for protein nutritional quality, microbiological quality, cookability, suitability in making *akara* and, in the case of whole seed, for milling characteristics.
3. Microbiology studies will determine the suitability of cowpeas and cowpea flour as substrates for growth and production of aflatoxin by *Aspergillus*. The influence of temperature, water activity and storage time on aflatoxin production will be determined.
4. Survey activities will involve completion of field work and data collection for the food science/human nutrition survey. Analysis of the data will be initiated for application to project objectives. Preparation of a summary and interpretation of data collected in the socio-cultural, socio-economic pilot survey will be sought.

A Program to Develop Improved Cowpea Cultivars for Production and Utilization in Semiarid Zones

I. PROJECT ROSTER

A. US Lead Institution: University of California (UC), Riverside

Principal Investigator:	Dr. A. E. Hall, Department of Botany and Plant Sciences, UC, Riverside
Co-Principal Investigators:	Dr. K. W. Foster, Department of Agronomy and Range Science, UC, Davis
	Dr. P. N. Patel, Department of Botany and Plant Sciences, UC, Riverside
Cooperators:	Dr. W. M. Jarrell, Department of Soil and Environmental Sciences, UC, Riverside
	Dr. T. F. Leigh, Department of Entomology, UC, Davis
	Dr. V. Marcarian,* Department of Plant Sciences, University of Arizona

B. Senegal Counterpart Institution: Institut Sénègalais de Recherches Agricoles (ISRA)

Principal Investigator:	Dr. Mbaye Ndoye, Head, Crop Production Department, ISRA
Adviser to Principal Investigator:	Dr. Mahawa Mbodj, Agronomist, ISRA
Coordinator:	Dr. Mamadou Ndiaye, Rhizobiologist, ISRA
Plant Breeder:	Mr. Ndiaga Cisse, Plant Breeder, ISRA
Advisor to US Team:	Mr. Samba Thiaw, Agronomist, ISRA
Plant Physiologist:	Dr. Thiaka Diouf, ISRA
Technician:	Ms. Khady Diop, Entomologist, ISRA
Bioclimotologist:	Dr. Claude Dancette, ISRA-IRAT
Cooperators:	Dr. M. Ly, Director, Department of Crop Storage, ISRA
	Dr. Mankeur Fall, Department of Cropping Systems, ISRA
	Dr. Moustapha Diop, Head, Louga Sub-station, ISRA

II. PROJECT OBJECTIVES

The long-term goal is to increase grain production and yield stability of cowpeas grown in hot semiarid zones by subsistence farmers. The objectives for the first five years are to:

*Dr. Marcarian is carrying out associated work on cowpea BNF at the University of Arizona.

A. Develop improved cowpea cvs and management methods for the semiarid zone of Senegal.

B. Contribute to the training of the ISRA cowpea research team.

C. Develop germ plasm and methodologies for improving cowpea production in semiarid zones throughout the world.

III. CHANGES IN OBJECTIVES

In addition to the original objectives, during the fourth and fifth years some emphasis will be given to obtaining useful baseline data and to local applied research on storage and marketing (since these are major constraints to increasing cowpea production and utilization in Senegal).

IV. RESEARCH OUTPUTS

A. Available for Immediate Use

The project has developed the following materials and technologies for use by cowpea researchers working in the semiarid tropics:

1. Improving Drought Adaptation
   a. Several extremely early cowpea strains have been selected by ISRA, based upon performance tests over three years in Senegal, from lines developed at UC, Riverside. These cowpeas are potentially useful in semiarid locations where the rainy season is extremely short.
   b. Based upon emergence from sand subjected to osmotic solutions, a technique for selecting drought tolerance has been developed by ISRA which appears to be superior to previous methods.
   c. A field selection procedure for improved rooting was developed which is being used at UC, Riverside to screen cowpeas supplied by cooperators of IITA (Ibadan, Upper Volta and Brazil) and ISRA.
   d. Genotypic differences were discovered by ISRA in BNF under field conditions in the semiarid zone of Senegal.
2. Improving Heat Tolerance
   a. Field screening in California demonstrated that many cowpea strains exhibit excessive floral abscission when subjected to hot weather at flowering.
   b. Climatological analyses of thermal regimes were conducted at UC, Riverside which indicate that cowpea cvs which tolerate high night temperatures at flowering would be useful in semiarid and subhumid West Africa and in India.
   c. Cowpea strains have been discovered by UC, Riverside which tolerate high temperatures at flowering. It was shown that two of these strains (Prima and Tvu 4552) are suitable for use as parents in breeding programs in that they both have the same major recessive gene for heat tolerance and they

produce a reasonable number of progeny which have heat tolerance and desirable agronomic characters. It is estimated that good seed quality can be recovered with only one backcross when Prima and Tvu 4552 are used as parents.

d. A field procedure was developed by UC, Riverside which can be used for early generation selection to incorporate heat tolerance into day-neutral cowpeas.

3. Improving Insect Resistance--Several cowpea strains with resistance to Lygus hesperus, including Bambey 12 and Bambey 30 from Senegal, were discovered by UC, Davis. This research is valuable for California agriculture because Lygus is the major insect pest and some of the resistant genotypes were provided by this CRSP. The research was partially funded by California farmers. The techniques that were developed may be useful for cooperators in other countries.

B. Available for Use within 1-2 Years

1. On-farm tests of the extremely early cowpea lines will be conducted in Senegal in the summer of 1984, and it is anticipated that farmers will begin to use some of these lines within two years.
2. Beginning January, 1984 heat-tolerant genotypes developed by UC, Riverside which have genetic backgrounds from cowpeas presently grown in Senegal and California will be available for cooperators.
3. Genotypes with different canopy characteristics and information concerning inheritance developed by UC, Davis will be available for cooperators within two years to facilitate the breeding of "bush" and "soybean" type cowpeas.
4. On-farm and on-station tests of cowpea storage methods, using sealed drums, will be initiated in October, 1983, and it is anticipated that farmers will begin to use one of these methods within two years.

V. TRAINING OUTPUTS

A. United States

1. Degree Training--Ms. C. Nielsen obtained an M.S. in plant science from UC, Riverside in September, 1983 with research funded by this CRSP and a scholarship from UC, Riverside. Ms. B. Robertson is working on a Ph.D. in genetics at UC, Riverside. It is anticipated that she will complete the degree in 1984. Her research is funded by this CRSP and a scholarship from UC, Riverside. Mr. J. Ehlers is working on a Ph.D. in genetics at UC, Davis with funding by the CRSP.
2. Non-Degree Training--None.

B. Senegal

1. Degree Training--Mr. N. Cisse obtained an M.S. in agronomy at UC, Davis in July, 1983 with research funded by the CRSP and a

scholarship from USAID-Senegal. Mr. S. Thiaw is pursuing a B.S. in plant science at UC, Riverside with total CRSP support.

2. Non-Degree Training--The Senegalese PI, Dr. M. Ndoye, participated in the International Integrated Pest Management Workshop held in Brazil, April, 1983.

C. Other Developing Countries

1. Degree Training--Mr. H. Elowad is enrolled in a Ph.D. program in botany at UC, Riverside. His research is funded by the CRSP and a scholarship from the USAID-Western Sudan Agricultural Research Project (WSARP). Mr. I. Dow El Madina is pursuing an M.S. degree in plant science at UC, Riverside with research also funded by the CRSP and a scholarship from USAID-WSARP. It is anticipated that his degree will be completed in 1985. Mr. M. Warrag completed a Ph.D. in botany at UC, Riverside in March, 1983. His research was partially funded by this CRSP and a scholarship from the Sudan.

   As part of the cowpea BNF work being done under the direction of Dr. Marcarian at the University of Arizona, Mr. Ibrahim Mohamed (Sudan) is pursuing a Ph.D. degree, and Mr. Haile Tewolde (Ethiopia) and Mr. Mohamed Abbas (Sudan) are enrolled in M.S. programs.

2. Non-Degree Training--Mr. H. Elowad participated in a farming systems workshop sponsored by the University of Florida Farming Systems Support Project, September, 1983. Mr. Elowad, Mr. Abbas and Mr. Mohamed participated in the BNF Workshop held in Madison, Wisconsin, July 18-20, 1983.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. Intranational--UC-Farmer Organization in California--The cowpea growers of California are closely linked, through providing grants, to the cowpea research program of Dr. K. W. Foster and Dr. A. E. Hall, and in this way they are both contributing to and benefiting from this CRSP project.

B. International

1. UC, Riverside-Sudan--Dr. Dafalla, leader of the USAID-funded WSARP visited UC, Riverside in September, 1982. The following cooperative ventures were initiated:
   a. Mr. I. Dow El Madina, a student, joined the project at UC, Riverside in January, 1983.
   b. UC, Riverside student, Mr. H. Elowad, transferred to WSARP.
   c. Cowpea strains developed by this CRSP were sent to the Sudan for testing by WSARP.
   d. The US PI agreed to visit WSARP in the Sudan in September, 1984 and is encouraging WSARP to become involved in IITA's regional cowpea trials.

2. UC-IITA-ISRA
   a. In early December, 1982 a meeting was held at UC, Riverside in which Drs. B. B. Singh and Earl Watt from IITA, Ibadan, and Brazil discussed cooperation and coordination of cowpea improvement research and training with the US team.
   b. ISRA representatives visited the IITA/SAFGRAD projects in Upper Volta with the US PI in September, 1982.
   c. Dr. M. Ndoye attended the IITA workshop in Brazil in April, 1983. An ISRA team plans to visit IITA, Ibadan, in October, 1983.
3. UC-ISRA
   a. In January, 1983 the annual planning meeting was held at UC, Riverside with representatives from ISRA. The US PI visited Senegal in August and September, 1983 to work with the ISRA team and escorted Mr. Samba Thiaw back to UC, Riverside to begin a program of study. The project can now benefit from the advice that Mr. Thiaw can provide concerning matters pertaining to Senegal.
   b. Dr. K. W. Foster visited Senegal in September and October, 1983 to collect germ plasm with Mr. Ndiaga Cisse and advise him concerning initiating his cowpea breeding program.
   c. Dr. W. M. Jarrell visited Senegal in September and October, 1983 to assist in the measurement of BNF and mycorrhizae and to provide advice concerning the mineral nutrition of cowpeas and proposed fertilizer studies. Mutual understanding among UC and ISRA scientists has increased considerably during this last year.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States--UC, Riverside is substantially contributing to the administration of this project through:
   1. The time of the PI, Dr. A. E. Hall, and that of the office staff in the department.
   2. Research man-hours of Dr. Foster, Dr. Hall and the two technicians.
   3. Fellowships provided to two students by UC, Riverside and to three students by USAID.
   4. The Blackeye Varietal Council and UC, Riverside contributing the funds needed to fabricate a cowpea thresher (value $35,000) which is absolutely necessary for the project.
   5. The use of the extensive network of field stations for field research which is provided at only minimal cost to the project.

B. Senegal--ISRA is making major contributions to the project through:
   1. The salaries of all of the scientific staff and, until recently, all of the permanent technical staff and the drivers.
   2. Extensive field stations at no cost to the project.
   3. Until recently, all costs of transportation within Senegal.

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

The major constraints to achieving the long-term goal are the needs to strengthen the on-farm research capabilities of ISRA and the extension capabilities in Senegal. Several USAID projects presently underway in Senegal are focusing on these areas and substantial improvements have been made in recent years, but achieving a totally integrated system of extension and research will take a few more years. Some of the potential trainees from ISRA will require five years in US universities to obtain B.S. and M.S. degrees. The stated objectives should be achieved within the five years originally planned, but attaining the full value of the project will take longer.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

A. Developing Improved Cowpea Cvs

1. During the past three years, ISRA has been conducting an extensive varietal testing program with cowpea strains from many sources including UC and IITA. These tests indicate that four of the UC, Riverside strains (1-2-1, 2-13-4, 3-4-11 and 3-4-13) have improved adaptation to drier locations due to their capacity to produce substantial grain yields only 60 days after sowing. These cowpeas have produced 1.1 ton/ha in a dry location with only 180 mm of rain and sandy soil and as much as 2.4 ton/ha in wetter conditions. These early cowpea strains will be included in on-farm tests in 1984 together with selected local and IITA materials. Some of these materials will undoubtedly prove to be superior to local varieties in on-farm tests with respect to yield, management requirements and consumer acceptability.
2. The second phase will involve the breeding of cowpea cvs with substantially higher productivity and stability in infertile soils and uncertain rainfall by the ISRA cowpea team. The program at UC, Riverside has already developed heat tolerant cowpeas with genetic backgrounds from local cowpeas from Senegal (Ndiambour, Mougne, Bambey 21 and 58-57) to give the new ISRA cowpea breeding program a fast start. The UC, Davis program has developed germ plasm and information on inheritance which will enable the ISRA team to efficiently modify plant morphology in developing both erect and prostrate varieties. The ISRA team has developed a technique for selecting for drought tolerance in cowpeas which could assist them in selecting drought resistant cowpeas. In addition, they have discovered differences in BNF under field conditions (cv Ndiambour was superior in BNF to Mougne even though their growth habits and phenology are similar). This information should assist the ISRA team in choosing parents for their crossing program.

B. Developing Improved Management Methods

1. The hairy caterpillar (*Amsacta moloneyi*) is a major cowpea pest in the drier part of the semiarid zone. The biological control agent, *Bacillus thuringiensis* (BT), used in conjunction with

light-trap information and field surveys, may provide an effective solution to this problem and on-farm tests are planned for 1984.

2. The following cropping systems have performed adequately in on-station tests: for the drier locations, main season intercrops with pearl millet and sole crops of cowpeas and for the wetter locations in the semiarid zone, a relay crop of cowpeas sown into pearl millet at heading and sole crops of cowpeas. A varietal intercrop should be tested which consists of alternating rows of early-erect and prostrate-late cowpeas because this may result in increased stability and use for forage and food. Measurements of hydrologic balance were made which should enable the ISRA team to predict the success of different cropping systems in different ecological zones.
3. On-farm tests are planned to examine whether presowing applications of various phosphatic materials are more economic than either no inputs or the presently recommended small application of complete fertilizer. Insecticide applications at flowering may not be needed in the drier areas but are essential in the wettest part of the semiarid zone. Consequently, on-farm tests can proceed in the drier areas, where most of the cowpeas are grown, without applications of insecticide during the growing season. Work on the use of minimal insecticide sprays with environmentally safe pyrethroids and resistant strains of cowpeas from IITA could provide a long-term solution for the wetter locations.
4. Storage and marketing represent major constraints to improving the production and utilization of cowpeas. The ISRA cowpea team proposes to conduct on-station and on-farm tests of simple sealed-drum storage systems beginning in October, 1984. Consequently, for the major cowpea production area in drier parts of Senegal, rapid progress is being made toward the development of complete improved systems of cowpea production and storage.

C. Contributions to Training of the Cowpea Research Team--Training was provided to the cowpea breeder (Mr. Nidaga Cisse, M.S. agronomy, UC, Davis, July, 1983). Many short-term informal training opportunities have been provided for various ISRA team members. The main deficiency in the ISRA cowpea team at this time is in agronomy. Attempts are being made to solve this by the training of Mr. Thiaw at UC, Riverside.

D. Developing Germ Plasm and Methodologies for Improving Cowpea Production in Semiarid Zones Throughout the World--Climatological analyses of thermal regimes have been conducted which indicate the regions of the world that would benefit from tolerance to high night temperatures at flowering (these regions include semiarid and subhumid West Africa and India). Heat-tolerant germ plasm is being developed for use by cowpea breeders in these zones. Tests with

early cowpeas developed at UC, Riverside and IITA indicate that they may be complementary with the ability to perform well in different parts of the world. Field screening methods have been developed for heat tolerance at flowering, early day-neutral phenology and improved rooting which take advantage of somewhat unique environmental conditions in California. Screening has begun on cowpeas from cooperators in ISRA, IITA and elsewhere for all of these characters.

X. BASELINE DATA

ISRA scientists conducted considerable research in Senegal in the past on cowpea production systems. Consequently, the team has a reasonable understanding of present production areas and methods. Visits by the ISRA and UC teams to farmers' fields with members of the extension organization and on-farm research during the last three years have updated the information. A synthesis is being attempted of presently available reports on cowpea production in Senegal. Information concerning storage, marketing and consumer preferences is not complete and is being supplemented by on-farm studies which are beginning at this time.

XI. FUTURE PLANS

A. Proposed Changes
1. Project Objectives--None.
2. Personnel Changes--Increased involvement of the crop storage and cropping systems departments of ISRA is anticipated.
3. Relocation--Increased involvement with WSARP is planned but the contributions to ISRA, Senegal, will not be reduced.
4. Project Strategies--Increased emphasis will be given to on-farm research and the cowpea breeding, agronomy and storage projects of ISRA and to the synthesis and acquisition of baseline data.

B. Proposed Plan of Work for FY 84
1. UC, Riverside
   a. Extend climatological analyses of thermal regimes where cowpeas are presently grown to determine those areas where heat-tolerant cowpeas are needed.
   b. Continue the development of heat-tolerant genotypes in different genetic backgrounds for cooperators and investigate the various reproductive processes which are damaged by heat and the inheritance of heat tolerance.
   c. Evaluate a greenhouse system for screening photoperiod-sensitive cowpeas for tolerance to high night temperatures.
   d. Evaluate new sources of earliness and heat tolerance obtained from India and study inheritance and environmental interactions.
   e. Continue screening for cowpeas with improved rooting.
   f. Continue comparative studies on the ureide and AR methods for measuring BNF to develop a more effective screening method for the ISRA breeding program.

g. Continue mineral nutrition studies with cowpeas emphasizing nitrogen and phosphate.
h. Conduct preliminary yield trials to evaluate new heat-tolerant lines.
i. Dr. Hall will visit Senegal and the Sudan in the late summer, 1984.

2. UC, Davis
   a. Continue research on the development of cowpea lines with different canopy ideotypes and determine the inheritance of canopy characteristics to facilitate the breeding of cowpeas that have increased yield potential or improved adaptation to semiarid environments.
   b. Evaluate the performance of lines with contrasting canopies and the interactive effects of different plant populations and spacings.
   c. Search for a non-nodulating cowpea line to facilitate BNF studies.
   d. Begin evaluating the cowpeas, under California conditions, which were obtained in the CRSP germ plasm collection trip in Senegal.
   e. Dr. Foster will visit Senegal in 1984 to assist the breeding program.

3. ISRA
   a. Breeding--Continue cowpea varietal trials at Bambey and Louga and initiate on-farm tests with cowpea strains. Mr. Ndiaga Cisse will visit Ibadan in October, 1983 and UC, Riverside in January, 1984 to attend the annual planning meeting, select UC germ plasm and learn how to use an IBM personal computer.
   b. Rhizobiology--Continue evaluating BNF to assist the ISRA cowpea breeder in the choice of parents. Attempt to develop a BNF screening technique which can be used to screen larger numbers of genotypes. Dr. Mamadou Ndiaye will visit UC, Riverside in January, 1984 to attend the annual planning meeting and conduct cooperative research with UC, Riverside personnel on different methods for screening BNF.
   c. Physiology and agronomy--Screen cowpea genotypes for drought tolerance. Evaluate flower abscission in heat-tolerant lines supplied by UC, Riverside and local materials. Conduct trials to evaluate practical fertilizer treatments for cowpeas under farm conditions. Dr. T. Diouf will visit Ibadan in October, 1983.
   d. Bioclimatology--Analyze previous experiments and climatological data on hydrologic balance to predict the success of different cowpea cropping systems in different ecological zones. Conduct evaluations of selected cropping systems, including a varietal intercrop at Bambey and Louga.
   e. Entomology--Focus on solutions to the hairy caterpillar problem. Test the efficacy of BT during the dry season. Conduct on-farm tests in the Louga district with dusts of BT guided by information from light traps and field surveys.

Conduct evaluations of minimal insecticide sprays at flowering using insect resistant and susceptible varieties at Bambey and at Nioro du Rip. Dr. Ndoye will visit UC, Riverside in January, 1984 to attend the planning meeting, discuss methods for controlling the hairy caterpillar and discuss an education program for Ms. Khady Diop at UC, Riverside.

f. Cowpea storage--Surveys will be conducted on the efficacy of storage methods presently used for cowpeas by farmers in the Louga district. On-farm and on-station tests will be conducted of various simple sealed-drum methods of storage.

g. Synthesize available baseline data and baseline information gained from the germ plasm collection trip, on-farm research and surveys.

Breeding Beans for Disease and Insect Resistance and Determination of Economic Impact on Smallholder Farm Families

I. PROJECT ROSTER

A. US Lead Institution: Washington State University, (WSU)

Principal Investigator:	Dr. M. J. Silbernagel, Irrigated Agricultural Research and Extension Center (IAREC), WSU
Co-Investigator:	Dr. J. M. Due, Department of Agricultural Economics, University of Illinois (UI), Urbana
Research Technician:	Ms. L. J. Mills, Department of Plant Pathology, IAREC, WSU
Research Assistant:	Ms. M. White, Department of Agricultural Economics, UI, Urbana
Attendant:	Ms. D. A. Smith, IAREC, WSU
Advisor:	Dr. G. I. Mink, Department of Plant Pathology, IAREC, WSU
Nutrition Advisors:	Dr. H. H. Koehler, WSU Dr. B. G. Swanson, Department of Food Science and Human Nutrition, WSU
Administrator:	Dr. D. L. Oldenstadt, Associate Director, College of Agriculture, WSU
Administrator and Chair of CRSP BOD:	Dr. L. L. Boyd, Agricultural Research Center, WSU

B. Tanzania Counterpart Institution: University of Dar es Salaam (UDS), Morogoro

Principal Investigator:	Dr. B. F. Ndunguru, Chair, Department of Crop Sciences, UDS, Morogoro
Researchers:	Prof. C. L. Keswani, Crop Sciences, UDS, Morogoro Dr. J. M. Teri, Department of Crop Sciences, UDS, Morogoro Ms. M. E. Quentin, Department of Crop Sciences, UDS, Morogoro Dr. A. K. Karei, Department of Crop Sciences, UDS, Morogoro Dr. E. A. Manday, Department of Rural Economy, UDS, Morogoro Mr. R. Misangu, Department of Crop Sciences, UDS, Morogoro Dr. J.M.R. Semoka, Department of Soil Sciences, UDS, Morogoro Dr. M. P. Salema, Department of Microbiology, UDS, Morogoro

Dr. M. Seenappa, Department of Food Science, UDS, Morogoro
Dr. M. Mmbaga, Department of Botany, UDS, Dar es Salaam
Dr. A. J. Tesha, Department of Botany, UDS, Dar es Salaam

Administrator: Prof. M. L. Kyomo, Dean, Faculty of Agriculture, Forestry and Veterinarian Science, UDS, Morogoro

II. PROJECT OBJECTIVES

A. Through a breeding program, develop high yielding, widely adapted disease and insect resistant cvs of beans for the smallholder family.

B. Estimate the economic viability of the new cvs and their impact on women's roles in the production, consumption and marketing process.

III. CHANGES IN OBJECTIVES

A. Develop Screening Methods for Drought Tolerance in Beans (Dr. A. J. Tesha)--This change was instituted because many beans are grown in dry areas in Tanzania. It was approved by the BOD on September 20, 1983.

B. Develop a Methodology for Nutritional Improvement in Beans (Dr. M. Seenappa)--This was instituted because of the need to establish the nutritional role of beans in diets, develop acceptability criteria for new cvs and the need to improve bean cookability and nutritive value. It was approved by the BOD on September 20, 1983.

IV. RESEARCH OUTPUTS

A. Available for Immediate Use
1. The cv Kabanmima out-yields most cvs at cool-high elevation sites.
2. Growing mixed bean cvs reduces rust and ALS incidence and severity and increases yields 24%.
3. Cleaning seed lots reduces seed transmission of diseases and increases yields 17%.

B. Available for Use within 1-2 Years
1. Periodic oil treatment of bean seeds reduces bruchid damage in storage.
2. Natural plant extracts (neem, pepper) may be an effective alternative to insecticides to control pod borer damage in beans.

V. TRAINING OUTPUTS

A. United States

1. Degree Training--Ms. Patricia Miller is working on an M.S. degree at UI.
2. Non-Degree Training--Dr. M. J. Silbernagel, US PI, took a three-month (January-March, 1983) sabbatical to CIAT to work with Tanzanian trainees (Dr. Karel, Mr. Misangu, Ms. Gondwe) on this CRSP project and with Dr. Jeremy Davis on breeding snap beans for the tropics.

B. Tanzania

1. Degree Training--Mr. Jeremiah Rugambisa is enrolled in a Ph.D. program at UI in the Department of Agricultural Economics. His specialization is marketing. It is anticipated that he will complete the degree during the next year. Ms. Susan Nachimbi is in an M.S. program in the Department of Horticulture at UW. She will complete the degree in two years. A third Tanzanian graduate student at WSU returned home in June, 1983 because of a low grade-point average.
2. Non-Degree Training--Ms. Susan Nachimbi attended the BNF Workshop held at UW, July 18-20, 1983. Mr. Robert Misangu, M.S. plant breeder at UDS, Morogoro, Ms. Bette Gondwe, B.S. plant protection officer at the Tanzanian Agricultural Research Organization, Lyamungu, and Dr. A. K. Karel (male), entomologist, UDS, Morogoro received three to four months in-service training at CIAT under Ford Foundation sponsorship. Dr. A. K. Karel also spent one week in Goiânia, Brazil at the Integrated Pest Management Workshop held in April, 1983. This was CRSP funded. Dr. M. Mmbaga (female), plant pathologist at UDS, Morogoro took part in a one-week bean rust workshop in Puerto Rico in February, 1983. This was funded by the CRSP. Dr. M. Seenappa (male), food scientist at UDS, Morogoro, attended a one-week bean nutrition workshop at INCAP in Guatemala, August, 1983. This was CRSP funded.

C. Other Developing Countries

1. Degree Training--Mr. Wei-Young (Simon) Wang from Taiwan finished an M.S. degree on the serology of BCMV at WSU. He has begun a Ph.D. program on monoclonal antibody production in BCMV in the Department of Plant Pathology at WSU.
2. Non-Degree Training--None.

VI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES ESTABLISHED

A. United States

1. The six-way linkage between USAID-MSU-WSU-UI-UDSM and USDA is running smoothly, except for the WSU match fund requirement discussed in section VIII, below. The USDA program now includes bean germ plasm enhancement work, partly as a result of the

Tanzanian and CIAT linkages. Dr. Jean Due reports the UI is getting involved in more international activities, partly as a result of her successful involvement with the Bean/Cowpea CRSP.

2. The linkage with CIAT for in-service training of Tanzania scientists and for coordination of the breeding program efforts with Dr. Davis (CIAT bean breeder responsible for East Africa) has proven very beneficial.

B. Tanzania

1. The bean project at UDS, Morogoro has good working relationships with the USAID Mission (Mr. Ken Lyvers), the Oregon State University Farming Systems Project (Dr. Frank Conklin), the Tanzanian Agricultural Research Organization (Dr. Jonah Kesembe) and Uyole Agricultural Research Center (Dr. John Liwenga).
2. A second annual bean researchers workshop was recently held at Morogoro, sponsored by this project.
3. A joint proposal for outside funding is being prepared in order to get needed equipment and facilities for bean seed threshing, cleaning and storage at the Tanzanian Agricultural Research Organization and Uyole Agricultural Research Center.

VII. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

These have been partially described under sections V and VI. In addition:

A. United States

		Percent of CRSP
1.	Dr. M. J. Silbernagel (WSU)	20%
2.	Dr. J. M. Due (UI)	24%
3.	Ms. L. J. Mills (IAREC, WSU)	100%
4.	Ms. M. White (UI)	100%
5.	Ms. D. A. Smith (IAREC, WSU)	100%
6.	Dr. G. I. Mink (IAREC, WSU)	15%

B. Tanzania

1.	Dr. B. F. Ndunguru (UDS, Morogoro)	20%
2.	Prof. C. L. Keswani (UDS, Morogoro)	20%
3.	Dr. J. M. Teri (UDS, Morogoro)	20%
4.	Ms. M. E. Quentin (UDS, Morogoro)	20%
5.	Dr. E. A. Manday (UDS, Morogoro)	20%
6.	Dr. J. M. R. Semoka (UDS, Morogoro)	20%
7.	Dr. M. P. Salema (UDS, Morogoro)	20%
8.	Dr. M. Seenappa (UDS, Morogoro)	20%
9.	Dr. M. Mmbaga (UDS, Dar es Salaam)	20%
10.	Dr. A. J. Tesha (UDS, Dar es Salaam)	20%
11.	Dr. A. K. Karel (UDS, Morogoro)	60%
12.	Mr. Misangu (UDS, Morogoro)	60%

VIII. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Financial--None, except considerable paperwork is involved in getting funds spent according to the protocols of USAID, WSU and UDS, Morogoro.

B. Administrative
1. The issue of the WSU matching fund requirement needs to be resolved because of Dr. Silbernagel's position as a USDA employee.
2. Some delays in obtaining international travel clearance were experienced.

C. Technical and Human
1. The Tanzanian co-investigators are heavily involved in teaching and other university functions, so most of their bean research is indirect, through the supervision of student projects.
2. There is a lack of technically trained field and lab research assistants. This limits the amount of field work each staff member can manage.
3. Other personnel matters include the following:
   a. Dr. Mmbaga recently had a baby and is on maternity leave.
   b. Ms. Quentin has been very ill this past year.
   c. Dr. Anandajayasekeram left UDS, Morogoro. He has been replaced by an agricultural economist, Dr. E. Manday.
   d. Dr. Chowdhury, microbiologist, has left UDS, Morogoro and the N_2-fixation studies are being done by Dr. Selema.
   e. Dr. Jana has left UDS, Morogoro. He will be replaced by Dr. Tesha, UDS, Dar es Salaam who will work on drought resistance.

D. Physical, Logistical--The project is catching up to the purchases needed to get the program entirely in motion. There are three locations in Tanzania where bean breeding research activities are in progress. None have adequate equipment or facilities for seed harvest, cleaning or storage. CRSP money is being used to get Morogoro the needed equipment and facilities. Efforts are underway to attract outside funding to similarly equip the Tanzanian Agricultural Research Organization and the Uyole Agricultural Research Center.

E. Socio-Political--The cv Kabanima is excellent for high cool environments but has not been assimilated into the national system for production and distribution to those areas. The present extension system needs to be examined to find out why this has not been done. Supplemental pathways to cv promotion and utilization need to be considered, i.e., through the public school system, gardening classes and/or missionaries throughout the country.

IX. PROGRESS TOWARD PROJECT OBJECTIVES

A. Current year

1. BCMV Research--Prosser, Washington (Dr. Silbernagel and Ms. Mills)
   a. The strain of BCMV from Tanzania is the most severe known; very few of the Tanzanian cvs used as parents are resistant. Similar strains can be detected by serologic techniques developed by Mr. Wang and Dr. Mink.
   b. Progress continues in breeding beans for BCMV and Halo Blight (HB) combined resistance.
2. Socio-Economic Studies--UI and Tanzania bean growing regions
   a. Researchers Due, Anandajayasekeram, Modoe and White looked at farm families in the Morogoro region, and Due and Manday studied farm families in the Arusha region. These are excellent socio-economic background studies which include a comprehensive view of the role of beans in family labor, food and income.
   b. Socio-economic data were collected in 1982 and analyzed in 1983 for an additional 60 bean growing families in the Mgeta area. These families farmed 2.2 ha of which .5 ha were in beans. About 61% of the total production was consumed and 39% sold. Beans are intercropped with maize in November-December, while the second crop is monoculture in April-May. Favorite cvs were Kibwebwe and Kenya. Beans accounted for 22% of total hectarage but only 14% of the total value of production. Of the beans grown, 33% were consumed and 67% sold, contributing 24% of total cash income of the farm families. Husbands and wives together select bean seed for planting.
   c. Socio-economic data were collected from another 88 families in the Arusha region. Of the agricultural labor, 51% is by female family members in the Amereru region and 42% in Hanang district. The analysis of these data will be completed in 1984.
3. Pathology--Tanzania
   a. Mr. Ishabairu and Dr. Teri found less disease--rust and ALS--when bean cvs were grown in mixture and 24% higher yield.
   b. Mr. Pyuza and Prof. Keswani isolated and cultured ALS from several production areas and are developing inoculation and screening methods.
   c. Ms. Shao (Uyole) found that cleaning a seed lot increased germination by 4% and yield by 17%. Wet season anthracnose caused a mean loss of 46%, ALS 42% loss and rust 37% loss. These losses cost growers $425/acre.
   d. In time of planting studies, moisture stress was more limiting than diseases, so growers cannot plant late to avoid diseases.
   e. Ms. Gondwe evaluated the disease reactions of a large local and imported collection.

4. Agronomy, Physiology--Tanzania
   a. Mr. Magehema and Dr. Ndunguru, and Mr. Rweyemau and Dr. Ndunguru showed that optimal growth and yield of beans could be maintained by organic composts which could be produced by small holders.
   b. Dr. Semoka and Dr. Chowdhury found that B and Mo were not limiting soil nutrients in the BNF process.
   c. Dr. Tesha is trying to develop laboratory screening techniques to identify drought resistance.
   d. Dr. Seenappa initiated studies on the nutritional role of beans and the identification of acceptability criteria among smallholder families. Beans supply an estimated 72% of the dietary protein, mostly as dry beans, although a small amount is also consumed as pods and fresh shelled beans. Most people (92%) preferred large dark red seed types.
5. Entomology--Tanzania
   a. Mr. Hongo and Dr. Karel found that neem and hot pepper extracts protected beans from insects.
   b. Mr. Matee and Dr. Karel found that Pyrethrum seed dressing was effective in controlling bean fly damage and raised yields.
   c. Mr. Rwamugira and Dr. Karel showed there are considerable differences in cv resistance to bean fly damage.
   d. Dr. Karel found that pod borer damage (as high as 24-52%) could be prevented by use of insecticides. He reported on the effects of insecticides and plant populations on bean yields.
      Yields at 200,000 plants/ha were higher than at 100,000, 300,000 or 400,000. Ootheca foliar damage was less at 200,000 plants/ha. Flower thrips seemed uneffected by population density. Pod borer damage was less at 200,000 and 300,000 plants/ha. Dr. Karel also studied the use of a biologic control agent, BT, against pod borer damage. He found BT effective against podborers, in combination with minimal use of timely chemical sprays for other pests.
   e. Ms. Quentin continued to monitor the incidence of insect pests through the bean growing season in the Mgeta region, while looking for evidence of bio-control factors like predators or parasites. She also surveyed village household storage methods and found that 17% bought their seed at the beginning of the planting season; the rest saved their own seed. Over 80% of those stored the beans in gunnybags where bruchid control was mostly by Malathion dust. Most stored one or two bags (80 kg/bag) per household. Losses due to bruchids are serious. Safe effective controls are being sought.
6. Breeding--Tanzania
   a. Mr. E. Mbaga, an agronomist, described the bean work in progress at Lyamungu by himself, Ms. Betty Gondwe, a pathologist, and Mr. Koinange, a bean breeder. They tested

a large local cv collection and breeding lines imported from various sources (including CIAT and Prosser). The best of these along with the best lines from Morogoro (Mr. Misangu) and from Uyole (Ms. Madata) will be included in a replicated national yield trial in 1984. Mr. Misangu and Prof. Keswani increased 153 F_2 populations sent from Prosser and observed them for field resistance and adaptation. Seed of survivors were replanted for increase and will be shared with the other research locations for screening to local diseases, insects and environmental extremes. Mr. Misangu is also developing an integrated breeding program to combine the disease resistance program with the insect resistance program and the environmental stress tolerance program (heat, drought, N_2-fixation). Breeding lines and hybrid populations will continue to be sent to Morogoro from Prosser and CIAT.

b. Ms. Madata described the bean breeding program at Uyole. They have identified some promising materials for mono and intercropping systems and also have initiated some on-farm testing of the better materials.

B. Cumulative to Date

1. The first and second year objectives are about 70% complete and the project is about 20% of the way toward completing the overall objectives. About 90% of planned activities for this period are in progress.
2. A better documentation of losses due to specific insects, diseases and environmental stresses is needed.
3. There has been a good start on the evaluation of biologic variability of the pathogens.
4. The breeding program progressed well; useful interim materials should be identified via a cooperative national testing program in the next year or two.
5. The new projects (N_2-fixation, drought, nutrition) will supplement and complement existing activities.

X. BASELINE DATA

The socio-economic smallholder family background information acquired so far will provide excellent baseline data against which to measure future effects of introduced changes in cvs, production and/or storage methods. See IX A 2.2

XI. FUTURE PLANS

A. Proposed Changes

1. Project Objectives

a. The proposed expansion of project activities into drought (Dr. Tesha) and nutrition (Dr. Seenappa) has been described in section III, above.

b. In the area of socio-economic background studies, a crop intensive series of farm family surveys is now needed. In this way the growers will be telling the breeders exactly what their acceptability criteria (preferences) are for future cvs; from the production, harvest, storage, marketing, preparation and consumption points of view.

2. Personnel changes--Several WSU contributors are being added to the project.
   a. Dr. Mink is advising a graduate student and will be involved in developing a rapid serologic diagnostic procedure for BCMV.
   b. Drs. Koehler and Swanson will help evaluate materials and advise the project members on nutritional matters.
   c. Dr. Boyd's time on the BOD is a WSU contribution to the Bean/Cowpea CRSP.
   d. Ms. I. K. Ndamugoba at the Tanzanian Agricultural Research Organization Station at Maruku (Westlake) will be collaborating with the Morogoro bean team.
3. Relocation--None.
4. Project strategies--None, except as indicated above.

B. Proposed Plan of Work for FY 84--The plan of work for next year has been developed.

ACRONYMS

AFS	Agricultural Field Services (Ministry of Agriculture, Botswana)
ALS	Angular Leaf Spot
AR	Acetylene Reduction
ARS	Agriculture Research Service
ATIP	Agricultural Technology Improvement Project
AUSUDIAP	Association of US University Directors of International Programs
AWID	Association of Women in Development
BCMV	Bean Common Mosaic Virus
BGMV	Bean Golden Mosaic Virus
BIC	Bean Improvement Cooperative
BIFAD	Board for International Food and Agricultural Development
BNF	Biological Nitrogen Fixation
BOD	Board of Directors
BT	Bacillus thuringiensis
BTI	Boyce Thompson Institute
CEPLAES	Centro de Planificación y Estudios Sociales (Center for Planning and Social Studies)
CESDA	Centro Sur de Desarrollo Agropecuario (South Center for Agricultural Development)
CIAT	Centro Internacional de Agricultura Tropical (International Center of Tropical Agriculture)
CNPAF	Centro Nacional de Pesquisa de Arroz e Feijão (National Center of Investigation for Rice and Beans)
Co-PI	Co-Principal Investigator
CpMV	Cowpea Mosaic Virus
CRSP	Collaborative Research Support Program
CSU	Colorado State University
cv(s)	cultivar(s)
DAR	Department of Agricultural Research (Ministry of Agriculture, Botswana)
DCAA	División de Ciencias Agrícolas y de Alimentos (Division of Agriculture and Food Science)
DRI	Desarrollo Rural Integrado (Integrated Rural Development)
EAP	Escuela Agrícola Panamericana (Pan-American Agricultural School)
EFSAIP	Evaluation of Farming Systems and Agricultural Implements Project
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Enterprise for Agricultural Investigations)
ERP	External Review Panel
FY	Fiscal Year
GERDAT	Groupment d'Etudes et de Recherché pour le Development de l'Agronomie Tropicale (Association for Studies and Research for the Development of Tropical Agronomy)
GI	Gastro-Intestinal
GLP	Grain Legume Program
GOB	Government of Botswana
HB	Halo Blight
HC	Host Country
HR	Hypersensitive Reaction
IAPAR	Fundacão Instituto Agronomico do Paraná (Agronomic Foundation and Institute of Parana)
IAREC	Irrigated Agricultural Research and Extension Center
IBIT	International Bean Yield and Adaptation Nursery
IBRN	International Bean Rust Nursery
IBYAN	International Bean Yield and Adaptation Nursery
ICTA	Instituto de Ciencias y Tecnología Agrícola (Institute of Agricultural Science and Technology)
IFPP	Integrated Farming Pilot Project
IITA	International Institute of Tropical Agriculture
INCAP	Instituto de Nutrición de Centroamerica y Panamá (Institute of Nutrition of Central America and Panama)
INIA	Instituto Nacional de Investigaciones Agrícolas (National Institute of Agricultural Investigations)
INIAP	Instituto Nacional de Investigaciones Agropecuarias (National Institute of Agricultural Investigations)
INTSORMIL	International Sorghum/Millet Collaborative Research Support Program
IPRC	Insect Pathology Resource Center
IR	Institutional Representative

IRA	Institut de la Recherché Agronomique (Institute of Agronomic Research)
IRAT	Institut Recherche Agronomique Tropicale
ISRA	Institut Senegalais de Recherches Agricoles (Senegalese Institute of Agricultural Research)
KSU	Kansas State University
MAG	Ministry of Agriculture
MDR	Multiple Disease Resistance
MDT	Mahalapye Development Trust
ME	Management Entity
MITA	Mayagüez Institute of Tropical Agriculture
MO	Management Office
MOU	Memorandum of Understanding
MSTAT	Micro Computer Statistical and Data Management Package
MSU	Michigan State University
NADP	Ngamiland Agricultural Development Project
NASULGC	National Association of State Universities and Land Grant Colleges
NifTAL	Nitrogen Fixation by Tropical Agricultural Legumes Research Project
PCCMCA	Programa Cocperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios (Central American Cooperative Program for the Improvement of Food Crops)
PI	Principal Investigator
PIP	Programa de Investigaciones de Produccion (Program for Production Investigations)
RAO	Regional Agricultural Officer
RH	Relative Humidity
RSP	Recurrent Selection Program
SAFGRAD	Semiarid Food Grain Research and Development Project
SEA	Secretaría de Estado de Agricultura (Secretary of State for Agriculture)
SEMRY	Rice production cooperative in Cameroon
SODECOTON	Cotton production cooperative in Cameroon
TARS	Tropical Agriculture Research Station
TC	Technical Committee
UC	University of California
UDS	University of Dar es Salaam
UF	University of Florida
UG	University of Georgia
UI	University of Illinois
UNE	University of Nebraska
UPR	University of Puerto Rico
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
UW	University of Wisconsin
WID	Women-in-Development
WSU	Washington State University
WSARP	Western Sudan Agricultural Research Project