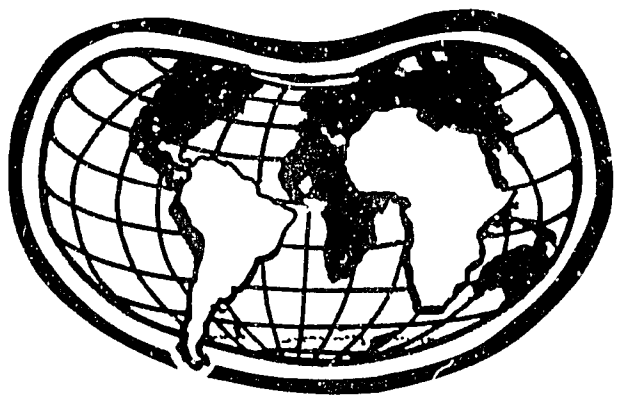
1984 ANNUAL REPORT
PART I, TECHNICAL SUMMARY

THE BEAN/COWPEA COLLABORATIVE RESEARCH SUPPORT PROGRAM (CRSP)

MICHIGAN STATE UNIVERSITY



The 1984 Annual Report: Part II, External Review Panel Report is available from the Management Office.

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Translations of the individual project reports into the Host Country official language are available from the Bean/Cowpea CRSP Management Office.

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COVER PHOTOS:

Front: Small Malawian boy in mother's field: beans intercropped with wheat.

Back: Guatemalan vendor sorting beans in a market.
Pests and diseases are serious problems in West African cowpea production.
Beans in pod and shelled.

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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" section of the US Foreign Assistance Act under which the program is funded. The CRSP 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 legumes. 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 all 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 multi-disciplinary 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.

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

CRSP research is concerned with genetics and plant breeding, entomology and pathology, agronomics, economics, nutrition and socio-cultural factors. A Logical Framework (Log Frame) and a global research plan developed jointly by HC and US colleagues form the basis for the eighteen collaborative projects.

The CRSP avoids unnecessary duplication of 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.

BEAN/COWPEA CRSP LOG FRAME

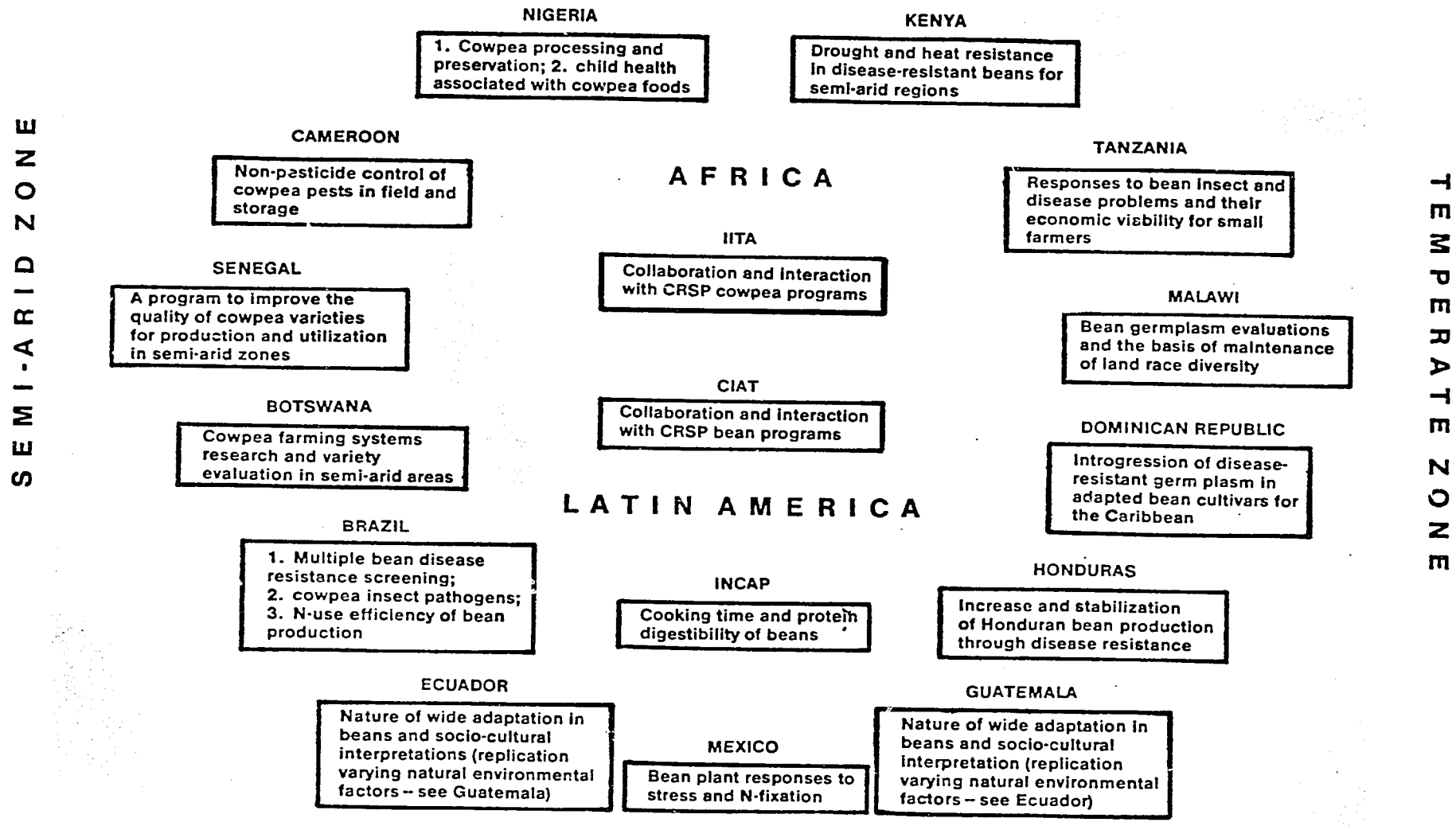
Program Goal	Objectively Verifiable Indicators	Verifiers	Assumptions
Make a significant contribution to the improvement of living conditions of small farm producers in developing countries and increase the availability of low cost, nutritious food in the marketplace for the rural and urban poor.	Development of important research results addressing identified constraints. Stronger national research program addressing identified constraints. CRSP products accepted by farmers, extension agents, HC private initiatives in ways which will advance goal. Increased participation of women.	Annual reports and positive TC/ERP reviews of progress. Increased overall size of national program research team with greater multidisciplinary competence and HC investment in the project. Adaptation of findings by external agents: farmers, IARCs, extension agents, commercial interests. Increased male and especially female CRSP graduates in the professional pipeline.	Food and nutrition problems in the developing nations can be solved in part through research. Collaboration between US and HC can be of mutual benefit. Achievement from this program can reach the rural and urban poor. Achievements of this Program can contribute to development in ways which do not increase the marginalization of women and their families.

Purpose	Objectively Verifiable Indicators	Verifiers	Assumptions
Organize and mobilize financial and human resources necessary for mounting a major multi-institutional US/HC collaborative effort in research and training. Provide the knowledge base necessary to achieve significant advances in alleviating the principal constraints to improved production, marketing and utilization of beans and cowpeas in HCs. Improve the capabilities of HC institutions to generate, adopt and apply improved knowledge to local conditions.	US/HC administrations' support of projects. HC and US teams functioning with good working relationships established. Research teams operating with effective level of equipment, supplies and technical support. Effective communications among all participants especially among those working on the same constraints across projects. Mechanism established for the identification and support of US and HC male and female CRSP students. Useful secondary data identified. Improved research infrastructure with laboratory and field research in process.	Smooth management with good communication with MO. US/HC quarterly and annual reports. Formal commitment of participants. Consistent pattern of student training established. Documentation of secondary data. Primary data analyses available in reports and publications. HC contributions to CRSP documented in each year's budget analysis.	HC will maintain interest in the commodity and in CRSP participation. Coups and other forms of political or social disturbances will not be of a magnitude at project sites as to severely and insurmountably affect progress. Necessary basic equipment, facilities and supplies will be available or acquirable within reasonable time frame. There is a sufficiently large pool of students from which to draw for advanced training at least at the secondary school graduate level.

Outputs	Objectively Verifiable Indicators	Verifiers	Assumptions
Strong, better quality yields produced under stressful conditions.	Yield increase under an array of stressful conditions to which produced varieties are resistant.	Yield data from local and national census.	There exists in the HC at least a skeletal infrastructure for information dissemination.
Greater understanding by US and HC collaborators of the socio-cultural and the agri-cultural environment.	Multidisciplinary research generated.	Reports of projects incorporate and integrate socio-cultural with agri-cultural information.	There are HC and US women sufficiently interested in advanced education and professional employment to work their way through the system when it is opened to them.
Products of research packaged appropriately for consumer use.	Informational materials available.	Materials acknowledged as received by many groups and increased consumer demand.	
Information dissemination for a variety of audiences.	Interest of wider international and national research and development community in products.	Requests from professional community for information and products increased.	
Production and utilization research findings useful for the wider research community.	Better health among those making use of project outputs.	Site visits.	
Many male and female graduates of training programs.	Male and especially female graduates returning to HC research institutions.	CRSP graduates identified in HC research positions.	
		Increased numbers of male and female students continually in short-term and long-term training.	

Inputs	Objectively Verifiable Indicators	Verifiers	Assumptions
Necessary long-term/short-term personnel from HC/US institutions who can communicate with each other.	Annual allocation from AID.	Increase in communications initiated by participants with one another.	AID will generate necessary approvals in timely fashion.
Financial contributions from AID and US and HC institutions.	CRSP funds flowing on regular bases to US and HC research teams.	Review of annual documents by TC and BOD.	AID will have funds available for use by the CRSP.
Management support from MO, US and HC institution administrations.	Annual plan of work and budget document with US/HC contributions.	AID letter of credit authorizing funds.	All parties making input will continue to feel the mutual benefits worth the investments.
Equipment such as vehicles, lab, field and office equipment.	Active backstopping by administrators of US institutions with effective levels of communication.	Regular reimbursement requests with quarterly reports.	
Facilities and supplies for HC/US teams.	Frequent and regular communication among AID, MO, US and HC.	Letters, phone calls and other expressions of interest and problem-solving support from US administrators.	
Information and support from external groups.	Participation in CRSP research and training activity by external groups (i.e., AID-sponsored FSR teams, IARCs, USAID missions).	AID approvals to purchase indicated equipment received.	
		Site visits.	
		Meetings and other forms of communication with external agents.	

GLOBAL RESEARCH PLAN
BEAN/COWPEA CRSP



General Features of CRSPs

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

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

2. Major contributions from US and HC institutions nearly equaling the contributions of the Agency for International Development (AID).

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

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 (CU), Michigan State University (MSU), University of California (UC), University of Georgia (UGA), University of Nebraska (UNE), University of Puerto Rico (UPR), University of Wisconsin (UW) and Washington State University (WSU).

2. Research teams from lead institutions are often augmented by investigators from other US institutions. One project includes five US institutions, one includes three, and five include two. 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 projects, institutions and investigators were identified. 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 (MO) staff. With a program management role, the WID specialist is well integrated into the on-going functioning of the MO. Responsibilities include drawing the attention of project investigators to project-related WID issues and encouraging the participation of women as students, technicians and researchers in the program.

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 HC equipment purchased in the US.

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 the MO to carry out its responsibilities. 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, Dr. B. L. Pollack, and a liaison to the Board for International Food and Agricultural Development (BIFAD), Mr. 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. The terms of office were changed this year to reflect the complexity of the tasks. Members now serve for three years. IRs are designated by the chief executives of their institutions to represent them in CRSP policy and administrative matters. These IRs are typically administrators of international agriculture programs, deans of agriculture or experiment station directors. The BOD elects its own chairperson and secretary.

The members of the BOD for Fiscal Year (FY) 84 were:

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

Dr. Charles Laughlin (Secretary)
Associate Director of the Agriculture Experiment Stations
University of Georgia, Griffin

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

Dr. Roger Uhlinger
Head, Department of Horticulture
University of Nebraska, Lincoln

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 and functioning of the MO.

4. Review and approval of project and MO budgets for FY 85.

5. Cumulative BOD actions on CRSP policy are as follows:

A. Bean/Cowpea CRSP Policy on US/HC Distribution of Funds:

(1) The policy previously adopted by the CRSP Board indicates that not less than 50 percent of USAID funds for support of projects be spent in or directly on behalf of Host Countries. In order:

(a) To insure CRSP focus on the solution of Host Country problems rather than on the maintenance of existing research programs of US institutions and

(b) To nourish a climate of collaboration and partnership between the US and Host Country Principal Investigators (PIs),

this policy is upheld and is to be based on each grant period.

(2) However, experience has demonstrated that the US PI is uniquely restricted when institutional indirect costs for project support are taken solely from the US 50 percent of the total funds. Therefore, the 50/50 split is to be applied to the total project budget exclusive of all indirect costs.

(3) Some projects have not settled into a spending pattern in the Host Country comparable to that in the US. Thus, in order to maintain a 50/50 split, more of each year's funds must be alloted 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 Host Country utilization of project funds. Therefore, where Host Country spending patterns are seriously below the expected level, the HC and US PIs will be requested to submit to the MO for TC discussion the reasons for the spending patterns and their suggestions for addressing the issue, including possible recognition of an unrealistic Host Country budget level.

B. Bean/Cowpea CRSP Policy on Institutional Involvement:

The Bean/Cowpea CRSP Board of Directors is concerned about the degree to which institutional participation occurs in CRSP projects beyond activities associated with the individual PIs. Of special concern is the extent to which PIs interact with their Institutional Representatives and the extent to which the administration of the lead institution is aware of the project's progress. It is strongly recommended therefore that at each institution significant steps be taken to strengthen institutional ownership through (a) internal project reviews with attention to greater institutional integration, (b) identification of project strengths and weaknesses with appropriate institutional response and (c) when relevant, institutional participation in on-site project analyses.

C. Bean/Cowpea CRSP Policy on Project Allocations:

If there is an effective and consistent quarterly spending pattern of 80 percent (actual costs reimbursement not including encumbrances), projects may be considered for allocations up to 100 percent of project

need as requested and demonstrated by the Principal Investigator. Maintenance of spending patterns less than 80 percent receives allocations commensurate with the prior spending pattern at a level which will discourage the accumulation of excess carry-forward funds.

D. Bean/Cowpea CRSP Policy on Training:

The Bean/Cowpea CRSP has as a major goal the strengthening of HC institutions through the training of HC nationals, a critical resource necessary for successful long-term research. To achieve this goal, CRSP projects are to give emphasis to the training of Host Country persons over the training of US persons. This policy adopts a Host Country priority rather than US exclusion and refers to both short-term training and graduate education.

E. Bean/Cowpea CRSP Policy on Participation of Non-CRSP Developing Countries:

Whereas the Bean/Cowpea CRSP has institution building and strengthening as a major goal, the BOD endorses the concept of CRSP Host Countries inviting scientists, representing limited-resource nations in CRSP regions of the world, to participate in Host Country collaborative research and training efforts which may provide mutual benefits.

The Technical Committee

The TC advises the BOD, ME and MO in areas of project management and technical research strategy and technology. 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 84 were:

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

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

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

Dr. George Hosfield
Department of Crop and Soil Sciences
Michigan State University

Ms. Kay McWatters (Secretary)
Department of Food Science
University of Georgia Experiment Station, Experiment

Dr. Donald Roberts
Insect Resource Pathology Center
Boyce Thompson Institute

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

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

1. Monitoring of CRSP projects and discussion with project leaders of the appropriateness of changes or additions in project objectives and strategies as these were proposed to the group.

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

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

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 1984 review focused on evaluation of the research and management of the projects at the US sites. Selected HC sites were also reviewed. Of particular significance were the ERP recommendations for individual project extensions. Those projects previously designated as troubled received special attention. The MO publishes the 1984 ERP report as Part II of its Annual Report.

The Management Office

The MO, the operational arm of the Management Entity (Michigan State University), has assumed the duties necessary to effect a successful collaborative research program. The responsibilities as stated in the grant document are:

1. Accept total bean/cowpea funds and responsibility for same.

2. Work out with each sub-grantee institution the structure, process and procedures for the re-allocation of funds.

3. Negotiate with each sub-grantee institution the desired backstopping to meet guidelines and regulations to meet performance objectives.

4. Develop detailed yearly budgets with the US and HC institutions.

5. Effect US agency approvals.

6. Effect necessary approvals from participating host governments and participating US institutions.

7. Continue "fine-tune" planning, assuring the integration of all Bean/Cowpea CRSP activities into a single research effort.

8. Meet regularly with and provide staff support for the Board of Directors.

9. Meet regularly with and provide staff support for the Technical Committee.

10. In cooperation with appropriate groups, develop evaluation plans, highlighting critical points in the research and indicating appropriate criteria by which to measure progress.

11. Receive and disseminate annual project summaries and other documentation as arranged.

12. Provide staff support for the External Review Panel.

13. Facilitate the auditing process.

14. Facilitate communication, information sharing and feedback among all appropriate parties, US and HC, with attention to cross-cultural understandings, translation of communications and national prerogatives.

15. Confer in advance with each US sub-grantee institution regarding travel procedures and regulations and other guidelines to avoid "disallowed" costs to any participating institution. Distribute and interpret amendments to Standard Provisions every six months or as issued.

16. Receive required fiscal documents and facilitate money flow.

The MO works closely with the sub-grantee institutions. Communication among the research teams insures maximum effectiveness of the program. To this end, regular written communications, conferences, etc. are sponsored by the MO.

By monitoring and facilitating the research and training efforts of the eighteen CRSP projects, the MO supports the development of effective relationships among the members of the cross-cultural, multi-disciplinary and bi-gender teams. A high level of MO activity has served the goals and objectives of the program during the past year. These efforts included (1) monitoring project activity in the US and at HC sites as needed, (2) providing support and guidance to all projects as appropriate, (3) reinforcing attention to the WID perspective, (4) reinforcing communication among the US and HC researchers,

administrators and management support groups (BOD, TC and ERP), (5) encouraging better project integration with the lead and HC institutions, (6) providing staff support to the BOD, TC and ERP--who together held eight meetings during the year, (7) carrying out the policies and recommendations of these groups, (8) maintaining information flow between the CRSP and AID/BIFAD, (9) receiving project reports and increasing published output and (10) representing the CRSP in wider national and international settings.

Staff

With nearly 100 percent new staff, the MO has demonstrated outstanding skill and dedication to program support. At the end of FY 84, the MO staff was as follows:

Director:	Dr. Pat Barnes-McConnell
Deputy Director:	Vacant
WID Specialist:	Ms. Anne Ferguson
Administrative Officer:	Mr. John Niles
Executive Secretary:	Ms. Sue Bengry
Secretary/Receptionist:	Ms. Irma Gutierrez

In March 1983, an automobile accident so incapacitated the newly appointed deputy director that he was unable to return to work. Thus, for nearly all of FY 84, the office has been without a deputy director. While a replacement is being sought, the existing staff organized to meet the critical and priority responsibilities of the office. While most of these responsibilities were covered, it was at considerable cost to the staff.

Communications

As the CRSP completes its fourth year of operation and as projects become more fully institutionalized, additional research findings are being generated and training efforts are being intensified. One of the primary responsibilities of the MO is to disseminate information about these achievements. This includes the following types of activities:

1. Making research findings available to researchers and to lay audiences in the US and the HCs.

2. Fostering the integration of the individual CRSP projects into a cohesive program through cross-project communications and activities.

3. Making presentations to appropriate organizations: AID, professional associations and conferences, HC and US institutions.

To insure that CRSP research findings reach a wide audience, the following publication series were initiated in FY 84:

Vanguard: Periodic reports on major, advanced research findings written for informed lay and academic audiences. The first in this series is:

Temperature x Photoperiod, Adaptation and Yield in Phaseolus Vulgaris by Dr. Donald H. Wallace, Dr. Porfirio N. Masaya and Mr. Paul A. Gniffke of the Guatemala/Cornell University project.

Research Highlights: Periodic reports on research in progress designed for lay audiences. Issues published in FY 84 are:

Developing Cowpea Varieties with Improved Yield under Conditions of Extreme Drought and Heat, Vol. 1, No. 1, by Dr. Anthony Hall, Senegal/University of California, Riverside project.

Five Improved Multiple Disease Resistance Lines Released, Vol. 1, No. 2, by Dr. Julio Lopez-Rosa, Dominican Republic/University of Puerto Rico project.

Fungal Disease in Leafhopper Control, Vol. 1, No. 3, by Dr. Donald Roberts, Brazil/Boyce Thompson Institute project.

Improving Food Accessibility Through Village Level Production of Cowpea Meal, Vol. 1, No. 4, by Ms. Kay McWatters, Nigeria/University of Georgia project.

New Bean Technology for Detection and Identification of International Seed Borne Viruses, Vol. 1, No. 5, by Dr. Matt Silbernagel, Tanzania/University of Washington project.

Two other series were also developed. The first is designed to assist on-going projects in achieving their objectives and the second to outline potential new directions in bean and cowpea research:

Women-in-Agriculture Resource Guides: Designed for specific Bean/Cowpea CRSP projects, these provide a summary of the Host Country small-farm sector with particular attention paid to women's roles in agriculture. Information on Host Country women's organizations and an annotated bibliography are included. Under the direction of the series editor, Ms. Anne Ferguson, the following Resource Guides have been completed:

Women in Agriculture, Cameroon. Prepared by Ms. Anne Ferguson and Ms. Nancy Horn

Women in Agriculture, Botswana. Prepared by Ms. Nancy Horn and Ms. Brenda Nkambule-Kanyima.

Monographs: The first report exploring potential new directions in research is:

Beans and Cowpeas as Leaf Vegetables and Grain Legumes by Dr. H. C. Bittenbender, Mr. Robert P. Barrett and Mr. Bernard M. Indire-Lavusa.

In addition, the following reports were published:

1983 Annual Report: Technical and Executive Summaries: These publications provide a review of the 1983 research for the eighteen projects. The Technical Summary in its entirety is available in Spanish. The summaries for the three Brazil projects are available in Portuguese and the Cameroon and Senegal summaries may be obtained in French.

1983 Annual Report: External Review Panel: This report provides an evaluation of the individual projects and the program as a whole conducted by a panel of seven distinguished outside researchers.

Collaborative Research in the International Agricultural Research and Development Network: A Case Study: This Bean/Cowpea CRSP progress report was compiled for the grant extension request and details research and training progress through spring 1984.

The Office also publishes a quarterly newsletter, Pulse Beat, and has developed a general Program Brochure and Women-in-Development Pamphlet.

Program integration is carried out through a variety of means. The Annual Reports, Research Highlights, Vanguard and Pulse Beat have been a particularly useful means of conveying information among projects in the CRSP as well as to outside individuals and organizations. In addition, they have acted as a catalyst in generating more research and discussion. Of equal importance to these published communications are the constant flurry of letters, phone calls and telexes which link projects to one another and to the MO. Further, personnel from the various projects communicate with one another for consultation in areas where additional expertise is needed. Through the Technical Committee, these persons also form multi-disciplinary technical assistance teams.

While publications represent an important means of communicating within the CRSP and to a broader audience, a number of formal and informal presentations on CRSP activities were made by MO personnel during the year at professional meetings and in the course of visits to project sites and to AID/Washington. In addition, the MO has received many visitors from HC and US institutions and other development organizations during the year.

Travel

Management Office staff travelled extensively in FY 84 to carry out their administrative responsibilities. On the domestic side regular trips were taken to Washington, DC to confer with AID. This included a presentation to AID and BIFAD for a three-year extension of the Bean/Cowpea CRSP. US lead institutions were visited to handle project management issues and problems. Staffing was provided for three BOD meetings, four TC meetings and one ERP meeting. The MO also arranged travel and meeting facilities for the CRSP management groups. Presentations were given at various national meetings and workshops.

MO staff visited the following Host Countries in support of project activities and to address problems identified by the ERP: Brazil, Cameroon, Dominican Republic, Guatemala, Honduras, Kenya and Nigeria.

The MO acts as a liaison between the projects and AID for international travel approvals. Procedures for obtaining international travel clearances were reviewed with Principal Investigators in an effort to reduce the number of last-minute requests and to insure that adequate information was provided to justify the travel. At the suggestion of AID, the MO is making plans to submit a CRSP FY 85 travel plan to expedite clearance approvals.

Equipment

The MO acts as a liaison between the projects and AID regarding approval for equipment purchases. The delays and uncertainty involved in obtaining equipment approvals have been a source of frustration for the MO and project PIs. In addition to the obvious impact on research, there are problems in determining the most effective use of funds. For instance, the majority of carry-forward funds in project budgets represent funds allocated for equipment that have not been approved by AID. The current list of outstanding equipment requests includes items that were submitted in 1982. A top priority for the MO in FY 85 is a resolution of this problem.

The MO, in cooperation with the Malawi project, purchased a WANG personal computer which is now hooked up to the WANG office word processor and the MSU CYBER mainframe. Use of the PC in analyzing and manipulating data is a less expensive alternative than relying entirely on the University's mainframe. The next step will be greater computerization of office data management and implementation of telecommunications between the MO and AID.

Technical Assistance

MO technical assistance activities included initiatives in the West Indies and Uganda. A four-person team visited the University of the West Indies (UWI) and the Caribbean Agricultural and Development Institute (CARDI) in July to identify cowpea research needs and to determine the extent to which those needs fit research gaps in CRSP activities. A proposal to add an informal, small-scale UWI/CARDI project to the Senegal/University of California, Riverside project has been submitted by Dr. A. E. Hall. Discussions will continue in FY 85 with support contingent on CRSP financial resources.

A two-person team visited Uganda to discuss and develop a scope of work for the CRSP/Uganda portion of the CRSP/CIAT East African project submitted to the AID Africa Bureau. Dr. Howard Schwartz, a pathologist from Colorado State University who was previously located at CIAT, was a member of the team that travelled through the bean-growing areas identifying constraints to bean production and exploring research options for Uganda. When the needed research was identified, various funding possibilities were discussed. The scope of work was forwarded to the Africa Bureau as part of the proposed CRSP/CIAT effort.

Women in Development

From its inception, the Bean/Cowpea CRSP has incorporated a strong women in development (WID) focus and has included a WID Specialist on its Management Office staff. As currently structured, the position is a full-time appointment with half time spent on WID and the remainder in more general program activities, including preparation of the newsletter and editing of other CRSP publications. Major goals with regard to WID include:

1. Assuring that gender issues are taken into account in information gathering. This requires an awareness of the ways gender influences resource allocation, decision-making processes and the division of labor within farming households.

2. Ascertaining that innovations such as improved seed varieties, new techniques and technologies are appropriate to the small farm context and do not marginalize women or increase their already heavy work loads.

3. Encouraging the participation of women in the projects as researchers, technicians and students. Over the long run these efforts promise to diminish male biases in research and hence contribute to more equitable and successful development efforts.

Toward these ends, the following activities were undertaken during FY 84:

1. Development of a workplan and a pamphlet that outline WID concerns with regard to the CRSP.

2. Completion of Women-in-Agriculture Resource Guides on Cameroon and Botswana plus initial work on the Guatemala Resource Guide. The purpose of these documents is to assist investigators in achieving project goals through reviewing secondary source materials on the HC small farm sector and women's roles in agricultural production.

3. Begin compiling a list of women's organizations in the CRSP Host Countries and a list of US and HC researchers who can serve as consultants to the projects in their efforts to better incorporate women.

4. Presentations on the CRSP Women in Development strategy and achievements in research and training to AID, BIFAD, the CRSP BOD, TC and MSU organizations.

5. Attendance at professional meetings such as the Farming Systems Conference, the American Anthropologicial Association Meetings and the Association of Women in Development Conference to represent the CRSP and to establish contacts useful to the program in achieving its goals. In addition, the WID Specialist participated in meetings and discussions with project personnel, visitors to the CRSP MO and various campus organizations.

6. Participation in the INCAP/Washington State University project's team meeting in Guatemala to identify a person to carry out a secondary data search of materials relevant to the Guatemalan Women-in-Agriculture Resource Guide and discuss holding a WID seminar in conjunction with the proposed summer 1985 Jean Quality Improvement Workshop.

Grant Extension

A major demand on the MO resources during the year was preparation of documentation for the three-year extension request and presentation of the materials first to the JCARD Panel on CRSPs and the Agricultural Sector Council Sub-Committee on Cereal Grains and Legumes and later to BIFAD and AID representatives.

The documentation, initially organized as a two-volume looseleaf notebook and later printed in bound form, was prepared with the assistance of the MSU Instructional Media Center and the MSU College of Agriculture and Natural Resources Information Services. The major document entitled Collaborative Research in the International Agricultural Research and Development Network:

A Case Study was, in effect, a three-year report of the Bean/Cowpea CRSP. It provides a program overview including planning process, goals, constraints, global plan, management organization and activity, composite figures on research organization and personnel, summary of research and training achievements, linkages with International Agricultural Research Centers, individual one-sheet project profiles and complete program budget summaries. More detailed information and materials on each of these items, including project Log Frames, evaluations, extension requests and US/HC letters of support, were also included. The CRSP publications, outlined previously, were part of this documentation.

Each of the projects provided illustrative slides which, when added to those taken by MO personnel in the field, contributed to the extension audio-visual presentation. The slide show was organized to highlight the collaborative nature of the projects and their achievements.

Recognition of program accomplishments was demonstrated by the unanimous support given by BIFAD and AID representatives for the requested three-year extension.

Collaboration with International Agricultural Research Centers (IARCs)

CIAT and IITA are the two IARCs associated with this CRSP. Representatives of their legume programs have participated in CRSP planning and served as technical advisors from the CRSP's inception. In 1984, Dr. Shiv Singh of IITA served on the CRSP Technical Committee. As well as reviewing projects and providing important technical input to program activity, he worked with the CRSP in planning and organizing a Worldwide Cowpea Conference at IITA in November 1984. Substantial CRSP funds were committed to this activity.

Following a CIAT workshop in the fall of 1983, the CRSP and CIAT submitted a joint proposal to the AID Africa Bureau for work in East Africa. The separate but well-integrated plans which made up the proposal were developed during several joint meetings and in collaboration with representatives of the appropriate Host Countries. In addition, discussions have been held with representatives of the United Nations Development Programme concerning joint work with CIAT on angular leaf spot.

As a result of extension approvals, increased interactions with and contributions from these centers can be anticipated. Rather than having one center's representative serve a two-year term, the two centers will now alternate representation on a meeting-by-meeting basis. Thus, the CRSP will more frequently benefit from the participation of both entities.

PROGRAM HIGHLIGHTS FY 84

Research Achievements

Collaboration of Host Country nationals with US persons from the Land-Grant system to carry out research critical to increasing the availability of beans and cowpeas is the primary purpose of the CRSP. In the three years of individual project existence, CRSP researchers have been making considerable progress. While some of the accomplishments reported this year were reported earlier in preliminary stages, work in FY 84 has given greater precision, reliability and validity to the findings. Some of the most notable achievements are listed below.

1. Fertile progeny has resulted from the successful crossing of tepary beans (Phaseolus acutifolius), a desert-adapted legume often classified as drought escaping, with common beans (Phaseolus vulgaris), a legume requiring more water and a longer growing season.

2. Black bean lines with genetic potential to fix high levels of nitrogen have been identified and disseminated to national programs for further breeding and on-farm trials, to CIAT for phosphorus evaluation trials, to other CRSP projects and to scientists in the US. Superior N-fixing strains of Rhizobium phaseoli have been identified under controlled conditions.

3. The Dominican Republic/University of Puerto Rico-University of Nebraska teams have released six new multiple disease resistant bean cultivars (one black, two red- and three white-seeded lines) to US, national and international bean improvement programs, including CIAT.

4. The Senegal/University of California, Riverside team has developed cowpeas which produced 500-1000 kg/ha in Senegal for two years when the rainfall was only 135 and 180mm and which gave substantial mature pods at forty-nine days. Local varieties produced around 200 kg/ha during these periods.

5. The Guatemala/Cornell University project has shown the photoperiod (latitude) x temperature (altitude) x bean genotype interactions to control maturity, adaptation and subsequent yield. The importance of this concept in breeding is demonstrated by the pending release for New York state of an early-maturing, photoperiod-temperature insensitive red kidney that yields 20 percent more per land area per growing season than the standard variety and is 43 percent more economical. When applied globally, this concept can divide the world into four major zones.

6. A new bean technology for detection and identification of seed-borne viruses was developed by the Tanzania/Washington State University team using monoclonal antisera and will be produced by private industry for use in international exchange of potentially useful breeding stock between national and international programs, including CIAT. This technique will also facilitate the screening of segregating populations in breeding programs.

7. The Brazil/Boyce Thompson Institute team has identified over 150 fungal disease isolates in Brazil for use by the scientific community as insect control agents.

8. Large collections of bean and cowpea germplasm have been made throughout Africa and Latin America.

9. In the US and in African and Latin American Host Countries, large numbers of local and exotic bean and cowpea lines have been screened for pest resistance, disease resistance, heat resistance and drought resistance.

10. Breeding programs were initiated incorporating these materials with those from the US collections and from the IARCs. These materials were also shared with national and international programs. Testing has begun at many sites offering an array of altitude/latitude variations.

11. One national germplasm guide, growing out of the extensive germplasm survey and research in the Host Country, has been published by the Host Country.

12. Basic research on the genetics of inheritance of resistance is making important progress.

13. Research on variations among strains of plant pathogens is generating information critical to disease control.

14. Interactions were identified among bacterial isolates, their concentrations and host plant genotypes as important components in disease control.

15. Insect control research on identified cowpea pests' life-cycles and reproductive habits is generating important findings.

16. Secondary research continues to generate important information on the role of women in food production.

17. Socio-cultural and socio-economic studies are providing important information which will contribute to decision-making in breeding programs.

18. Methodology is being developed for village-level production of cowpea meal acceptable for use in traditional foods.

19. An extensive survey of methods used for evaluation of bean quality has been carried out, and a report of these methods is being prepared for use by the scientific community.

20. Secondary research was completed on the eating of legume leaves and their role in traditional diets.

21. Appropriate farming implements were developed (jointly with other groups) which are suitable for an identified Host Country farming system and environment.

Details of the above and additional research progress are reported in the individual project reports.

Training Achievements

From its inception, the CRSP has emphasized the training of persons from the US and developing nations. As of June 1984, CRSP data on training for FY 84 were even more impressive than FY 83. Gains were made in the annual total number of people in training which reflected both continuing students from 1983 and new students added in 1984. In the non-degree category alone, which tends not to have continuing persons, the number of participants grew from 91 in FY 83 to 133 in FY 84. There was also an increase in the number of females enrolled in programs.

Gender: During FY 84, of the 116 enrolled in degree programs 71 (61 percent) were males and 46 (39 percent) were females. During FY 83, of the 75 people in degree programs 49 (65 percent) were males and 26 (35 percent) were females.

During FY 84, of the 133 people in non-degree programs 81 (61 percent) were males and 52 (39 percent) were females. During FY 83, of the 91 in non-degree programs 51 (56 percent) were males and 40 (44 percent) were females.

Overall, of the 249 people in degree and non-degree programs in FY 84, 152 (61 percent) were males and 97 (39 percent) were females. In FY 83, there were 166 trainees: 100 (60 percent) males and 66 (40 percent) females.

Country of Origin: In FY 84, of the 116 people in degree programs 45 (39 percent) were from the US, 52 (45 percent) were from CRSP HCs and 19 (16 percent) were from other developing countries. During FY 83, of the 75 people in degree programs, 28 (37 percent) were from the US, 33 (44 percent) were from CRSP HCs and 14 (19 percent) were from other developing countries.

In FY 84, of the 133 people in non-degree programs 19 (14 percent) were from the US, 108 (81 percent) were from CRSP HCs and 6 (5 percent) were from other developing countries. During FY 83, of the 91 people in non-degree programs, 14 (15 percent) were from the US, 68 (75 percent) were from CRSP HCs and 9 (10 percent) were from other developing countries.

Overall, for FY 84, of the 249 people in training programs, 64 (26 percent) were from the US, 160 (64 percent) were from Host Countries and 25 (10 percent) were from other developing countries. In FY 83, of the 166 people in training programs, 42 (25 percent) were from the US, 101 (61 percent) from HCs and 23 (14 percent) from other developing countries.

TRAINEES ON CRSP PROJECTS BY GENDER AND SOURCE OF FINANCIAL SUPPORT

	Males			Females			
Degree Programs	CRSP-Funded	Other Funds	Total	CRSP-Funded	Other Funds	Total	Grand Total
US Citizens	16	6	22	18	5	23	45
Host Countries	28	6	34	14	4	18	52
Other	12	3	15	4	0	4	19
Total	56	15	71	36	9	45	116

Non-Degree Programs	Males			Females			
	CRSP-Funded	Other Funds	Total	CRSP-Funded	Other Funds	Total	Grand Total
US Citizens	9	0	9	9	1	10	19
Host Countries	67	0	67	41	0	41	108
Other	5	0	5	1	0	1	6
Total	81	0	81	51	1	52	133
Grand Total	137	15	152	87	10	97	249*

*Some trainees participated in degree and non-degree programs and, in these cases, have been counted in both categories.

Three workshops were held this summer under CRSP auspices. A workshop on MSTAT, a computer program that assists agricultural scientists in designing, managing and analyzing experiments, was held at MSU under the sponsorship of the Malawi/Mexico/MSU projects. There were two sessions: August 20-24 and 27-31. A total of twenty-three people participated, twelve in the first session and eleven in the second. There were five US graduate students and fifteen Host Country graduate students attending, in addition to three HC Principal Investigators. The workshop, which presumed no previous micro-computer experience, was intensive. It stressed the fundamentals of micro-computer operation and familarized students with MSTAT capabilities.

The Third Annual Bean Workshop at the newly created Sokoine University, Morogoro, Tanzania was held August 27-28. It was sponsored by the Tanzania/-Washington State University project and provided students with the opportunity to present their senior research papers.

The First Regional Caribbean Seminar on Biological Nitrogen Fixation was held in Santo Domingo, Dominican Republic, August 6-10. This was sponsored by the Secretary of State for Agriculture (SEA) of the Dominican Republic, the University of Puerto Rico, the FAO and the Bean/Cowpea CRSP. Its principal organizer was Lic. Elfrida Pimentel (SEA) and a participant on the Dominican Republic/University of Puerto Rico CRSP project. Areas covered included the process of infection and nodulation; preparation and use of inoculants; rhizobium genetics, biochemistry, isolation, physiology and taxonomy; and statistics and experimental design applied to biological nitrogen fixation. Representatives from the Dominican Republic, Haiti, Puerto Rico, Trinidad/Barbados and the US attended.

BOTSWANA • COLORADO STATE UNIVERSITY

Development of Integrated Cowpea Production Systems in Semiarid Botswana

I. PROJECT ROSTER

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

Principal Investigator:	Dr. C. J. deMooy, Department of Agronomy, CSU (resident in Botswana)
On-Campus Representative:*	Dr. W. R. Schmehl, Department of Agronomy, CSU
Administrative Officer:	Ms. Maxine Tamlin, College of Agricultural Sciences, CSU
Contracts and Grants Officer:	Mr. Galen Frantz, Contracts and Grants Office, CSU
Institutional Representative:	Dr. Wayne Keim, Department of Agronomy, CSU

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

Principal Investigator:	Dr. K. Oland, Director, Department of Agricultural Research (DAR), MOA
Co-Principal Investigator:	Dr. David Gollifer, DAR, MOA
Assistant Research Officers:	Ms. Mmasera Manthe, DAR, MOA
	Mr. Peter Montshiwa, DAR, MOA
Technicians:	Mr. Efedile Mosarwe, DAR, MOA
	Mr. Thuso Nkago, DAR, MOA
US Research Associates:	Ms. Karen Conniff, Department of Agronomy, CSU
	Ms. Barbara deMooy, Department of Agronomy, CSU**
US Assistant Researcher:	Ms. Julie Concannon, Peace Corps

C. USAID Project Officer: Dr. Anita Mackie, Liaison Officer, USAID/Gaborone

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives: The general project objective is to identify and remove constraints in cowpea production which cause traditional low yield levels. Project objectives are designed keeping in mind that:

1. Improvements must be conceived at the grassroots level to be applicable to farmers' conditions.

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*Dr. Donald R. Wood was on leave during FY 84. Dr. W. R. Schmehl took over his Bean/Cowpea CRSP responsibilities for the year.

**Ms. Barbara deMooy returned to the US to complete requirements for an M.S. degree at Michigan State University, fall term 1984.

2. Recommended practices must be made specific for moisture and other environmental conditions.

3. Proposed solutions must so completely suit farmers that they will be hard put not to accept the improvements. Although not always specifically mentioned, project objectives are meant to lead to solutions designed for several categories of small farmers.

4. The needs of farmers in different resource categories must be borne in mind.

5. Separate solutions may be necessary for farmers using tractor versus animal draft power.

6. Solutions need to be sought for the special problems encountered by women farmers.

B. FY 84 Objectives: Many specific objectives pursued by the project are being worked on simultaneously:

1. Devise a set of tillage/planting practices whereby planting can begin immediately at the start of the rainy season.

2. Evaluate the merits of reduced tillage with simple tools, especially for sandy, non-compacting soils.

3. Initiate a continuing variety screening program involving local germplasm as well as exotic lines.

4. Undertake field research for improvement of cultural practices under specific sets of conditions.

5. Combine whole-plant harvesting techniques with a search for suitable varieties and machine threshing for greater returns on labor.

6. Incorporate resistance to Alectra vogelii into cowpea varieties once the trait is found by screening of cultivars by the Evaluation of Farming Systems and Agricultural Implements Project (EFSAIP).

7. Test research findings in farmers' fields with and without subsidized inputs.

8. Arrange self-evaluation meetings to solicit suggestions and opinions from peers.

III. CHANGES IN FY 84 OBJECTIVES: None.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Most of the constraints reported during FY 83 have been corrected by DAR management. An additional field technician was appointed.

B. Seed multiplication facilities which were lacking in FY 83 are much improved by allocation of two hectares of irrigable land to the project.

C. New irrigation facilities were installed during July/August 1984.

D. Transportation remains a problem. The DAR provides official vehicles on a day-to-day basis when possible. The project needs two vehicles of its own. After AID refused to purchase Toyota Land Cruisers, efforts are now underway to buy a US model. A project with seven researchers active in the field and with experiments scattered over a 1000 km radius needs regular access to vehicles.

V. PROGRESS TOWARD OBJECTIVES

The main objective for the second year of project operations was to expand field experimentation to the full scope described in the Project Paper.

A. Tillage/Planting Practices: Evaluation of the ridgeshaper/planter and cultivator/planter by joint efforts of EFSAIP and the project indicated that good crop stands can be obtained with minimal draft power. The reduced draft power requirements enable farmers to begin planting sooner after the start of the rainy season. Ten more ridgeshapers/planters were produced in local workshops and are ready for testing on a wider scale.

B. Tillage and Moisture Conservation: The cultivator/planter proved suitable for once-over strip tillage and planting on certain soils. Evaluation of the moisture conservation risk of compaction and the types of soil for which the implement can be recommended must be continued at several locations over several years.

C. Variety Testing: Screening of local germplasm and exotic lines received high priority. Replicated trials were conducted at five locations (see VI).

D. Cultural Practices

1. Mouldboard plowing and use of a row planter with a tractor were compared with a plowplanter using six oxen, cultivator/planter with two oxen and cultivator followed by ridgeshaper/planter. The seasonal conditions were not conducive to the test as no rainfall occurred after the date of planting. Two trials involving three dates of planting could not be interpreted because only one suitable planting period occurred during the season.

2. It was shown that thrips pose no economic threat in drought years.

3. Minimum row spacing in drought years is 100 cm.

4. Mulching reduced flower bud abscission, reduced maximum soil temperatures, increased available soil moisture and improved plant growth.

E. Harvesting Techniques: No data could be obtained since none of the cooperating farmers in the region had sufficient harvest to make comparisons or warrant the use of a machine.

F. Alectra vogelii: Research on this parasitic weed was conducted by EFSAIP. No project activity was needed.

G. Tests in Farmers' Fields: This new program was launched with collaboration from the government extension service (DAFS) and several farming systems groups in the country. The trials conducted (variety/spraying tests) were based on several findings of the previous year and turned out to be a success. Thirty extension officers participated and more than forty-five have expressed interest for next year.

H. Self-Evaluating Meetings: Three self-evaluating meetings were held with crop production officers, extension personnel and others. Each time, suggestions were made to further expand the range of topics covered in collaborative field experiments. This was considered in the design of experiments for the following year.

VI. RESEARCH OUTPUTS DURING FY 84

A. Current Research Efforts: Farmers in Botswana and surrounding regions with similar extreme climatic conditions urgently need new cowpea varieties capable of flowering and producing grain in as short a period as possible. These must be suitable under conditions where drought stress is broken by occasional rains at unpredictable intervals. Additional requirements of these varieties are a high degree of resistance to disease and insect pests and high yielding ability. Among many other desirable qualities is the capacity to recover from serious desiccation damage. This suggests high priority be given what may be termed the fast approach in variety development.

1. The fast approach

a. After identification of the variety ER7 as a temporary solution to the problem, the focus of attention has been on developing even better cowpea lines. The method followed was continued exposure of all promising materials to the variable ecological conditions in Botswana.

b. Progress in canopy development and flowering was recorded. Some lines managed to set pods and produce grain whereas most others succumbed to environmental stress. Forty varieties were selected for continued screening from more than 100 foreign accessions studied in the first year. These forty varieties were narrowed down to twenty-four during 1984. Approximately seventy-five new accessions from

IITA and the Semiarid Food Grain Research and Development Project (SAFGRAD) were added for screening during the past year. Twenty-three of these lines were selected for continued screening. It is anticipated that two or three out of the total of forty-seven varieties will be selected next year for seed multiplication and nation-wide testing.

2. The long-term approach

   a. The long-term approach began with local germplasm collection and evaluation in the field to be followed by breeding to incorporate missing traits into otherwise promising material.

   b. In anticipation of the project's expansion into crop breeding activities, cowpea breeders from IITA and SAFGRAD assisted with crosses between three or four local cultivars which displayed vigorous growth under drought conditions, desirable plant type, high yielding ability and absence of virus disease symptoms and exotic varieties having very early maturity and very high yielding capacity in their regions of origin. ER_7 was one of these exotic varieties. F_2 and F_3 materials derived from the crosses were made during 1983 and are now available for testing in Botswana. A consulting entomologist and a breeder/pathologist were appointed during 1984 to help accelerate development of local-base cowpea varieties.

3. Botswana germplasm collection and evaluation: The germplasm collection grew to just under 700 accessions, 246 of which were grown and evaluated in the field during the year. Another twenty-four lines, for which only a few seeds were available, first had to be increased in the greenhouse. Owing to drought, complete information was recorded on only 157 cultivars. These were classified using fifty-two descriptors as had been done in the previous year. The results are reported in the Botswana Cowpea Germplasm Catalogue, Vol. 2, published by the Ministry of Agriculture. This activity supports the national as well as the international breeding programs. It should be realized that changing weather conditions from season to season will affect comparisons between cultivars catalogued in 1983 (Vol. 1) and those described in 1984 (Vol. 2).

4. Search for aphid resistance in local germplasm: One hundred and sixty-eight cultivars from the germplasm collection were grown in the greenhouse, inoculated with aphids and evaluated for resistance. The search was successful. Four cultivars proved highly resistant to aphids in two separate, replicated trials. The cultivars were B031, a brown-seeded variety; B037, white-seeded with brown eye; B142, brown-seeded with black eye; and B232, cream-colored with brown eye. All four cultivars are described in the Botswana Cowpea Germplasm Catalogue. This activity was conducted in support of the local and foreign cowpea breeding programs.

5. Evaluation of percentage natural outcrossing: The percentage outcrossing was evaluated at 10, 20, 30, 40 and 50 cm plant spacing of two cowpea varieties, a white-seeded and a black-seeded one, in a replicated experiment with and without the natural insect population. The outcome will become known when the collected seed of the white-seeded variety is planted next season.

6. Determination of cause of excessive shedding of flowers in cowpeas: Nearly complete shedding of flowers and buds during bloom results in crop failure. The known causes of abnormally high flower drops are thrips and drought. An experiment was conducted with three soil moisture levels, each with and without the presence of thrips, to determine the contribution from each cause. It was found that the cause of excessive flower-drop was overwhelmingly due to drought stress. This will shift research emphasis from thrip control to varieties and breeding.

7. Search for appropriate cultural practices: Cultural practices concerning tillage, planting methods, time of planting, draft animal requirements, weeding and harvesting also deserve attention. Two implements were designed for planting with reduced draft animal requirements. One was produced by the project and the other by the agricultural engineering section of the DAR. Both offer opportunities for minimum tillage practices. Their range of application needs to be delineated.

8. Collaborative program with the Department of Agricultural Field Services: A collaborative program was set up to permit agricultural extension officers to widely test CRSP research findings in farmers' fields. Evaluation of the materials and practices by the extension officers and feedback from cooperating farmers served to suggest directives for research priorities, provide further improvement of techniques, acquaint the extension officers with Bean/Cowpea CRSP activities and distribute small amounts of seed and equipment to the farmers.

B. Available for Immediate Use

1. The cowpea variety ER_7, originating from Nigeria (IITA) which was officially released in Botswana last year, proved to be in high demand by the farmers. Since no supply of seed was available for distribution, access to ER_7 in 1983 was limited to contacts with the Bean/Cowpea CRSP and the Department of Agricultural Field Services (Extension Service) conducting collaborative field trials in farmers' fields. None of the cooperating farmers who had received ER_7 seed were willing to sell some of their ER_7 grain harvest to the project. This is indicative of fast acceptance of the new technology. During 1984, the seed multiplication unit of the DAR managed to produce eighteen tons of ER_7, all of which was distributed to the farmers.

2. The Botswana Cowpea Germplasm Catalogue, Volume 1, appeared in print during January 1984. The local germplasm collection program was continued and the results summarized in Volume 2 of the Botswana Cowpea Germplasm Catalogue, which was published in September 1984. Copies are available from the Director, Department of Agricultural Research, Private Bag 0033, Gaborone.

C. Available for Use Within One to Two Years

1. In collaboration with the agricultural engineering section of DAR, two minimum-tillage planters are in the testing stage: a cultivator/planter built by DAR and a ridgeshaper/planter produced by the project.

2. Two or three cowpea varieties capable of producing seed under Botswana's harsh ecological conditions may be expected to result from the on-going field screening program involving more than 200 exotic varieties introduced from IITA (Nigeria) and SAFGRAD (Burkina Faso).

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
Conniff	F	CSU	Agronomy	Ph.D.		Total
deMooy	F	MSU	Crop & Soils	M.S.		Total
Botswana Citizens:						
Manthe	F	CSU	Agronomy	M.S.		Partial
Montshiwa	M	CSU	Agronomy	M.S.		Partial
Others:						
None						

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
deMooy	F	MSU	MSTAT Wkshp.	MSU	One week
Conniff	F	CSU	Cowpea breed. strategies	IITA	One week
Botswana Citizens:					
Mosarwe	M	DAR	Cowpea agron.	IITA	Two months
Shubo	M	DAR	Cowpea agron.	IITA	Two months
Manthe	F	CSU	MSTAT Wkshp.	MSU	One week
Montshiwa	M	CSU	MSTAT Wkshp.	MSU	One week
Others:					
None					

In the US, Ms. Karen Conniff completed academic coursework and the preliminary exam for the Ph.D degree at CSU and, in September 1984, was transferred to Botswana for dissertation research. Ms. Barbara deMooy completed thesis research for a M.S. degree, followed by a year of regular project research in Botswana as a research associate and was transferred to Michigan State University (MSU) in August 1984 for fulfillment of academic requirements for the degree.

Ms. Mmasera E. Manthe commenced academic coursework leading to the M.S. degree at CSU and will continue thesis research at Sebele upon her return to Botswana in September 1985. Mr. Peter Montshiwa also commenced academic coursework leading to the M.S. degree at CSU in January 1984 and will return to Botswana in December 1984 for thesis research at Sebele. Short-term, non-degree training at IITA (Nigeria) was offered to Mr. Efedile Mosarwe, holder of a four-year diploma in agriculture from Botswana Agricultural College and technical officer with the project, and Mr. M. Shubo, holder of an agricultural certificate from the same college who is assigned part-time to the project in the Maun region. Both received two months training in all aspects of cowpea field research and breeding at IITA. Ms. Karen Conniff also received a week of training at IITA.

VIII. BASELINE DATA

The Agricultural Technology Improvement Project (ATIP) conducted cowpea baseline surveys in the Francistown and Mahalapye areas. The Francistown survey dealt with cowpea cultivation and utilization practices in the Tutume District. In all, 275 households were interviewed. The Mahalapye survey was administered to 49 ATIP farmers in the Shoshong and Makwate areas.

The project administered a woman farmers' survey to 170 households throughout the eastern provinces. Very useful data were gathered on traditional cultivation practices, insect infestation, constraints to increased production, varietal preferences for consumption, outlets for selling grain and utilization of residues for grazing.

It appears that drought and lack of seed are the main constraints to increased production. It was surprising that none of the surveys assigned great importance to tillage and harvesting problems. The women farmers did not emphasize tillage operations and implements or harvesting as constraints.

Interpretation of the surveys has not been completed. The relevance of the findings to project objectives should be the subject of several meetings with ATIP and extension service personnel.

IX. WOMEN IN DEVELOPMENT

A. United States

1. Three out of four US researchers resident in Botswana were women. They were involved in training under supervision of the PI.

2. A Women-in-Agriculture Resource Guide was prepared under the direction of Ms. Anne Ferguson of the Bean/Cowpea CRSP Management Office (MO). This document provides a review of the literature on the small farm sector in Botswana with special attention given to women's roles in agricultural production.

B. Botswana: One of the two assistant research officers assigned to the project was a woman. Besides conducting research, she received M.S. degree training. She will play an important role in project research policy in a few years.

Project impact on women's roles in agriculture was evaluated in the women farmers' survey discussed above and is bound to be significant because most cowpea farmers are women.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States

Personnel input: $36,992.00.

B. Botswana: GOB inputs for Bean/Cowpea CRSP Project

1. Facilities	Value (P/annum)
Office for agronomist, clerical support, postage and supplies	$1,000
Vehicle, maintenance and fuel	$5,000
Subsistence in travel status	$2,000
Land at experiment station and substations, tillage, fertilizers and other materials	$2,000
Laboratory support work	$5,000
TOTAL facilities	$15.000
2. Staff	
Two technical assistants, full-time, entomology	$6,000
One technical assistant, three months, plant pathology	$1,000
One technical officer, three months	$1,000
One assistant agricultural research officer, three months	$1,000
One technical assistant, three months	$1,000
TOTAL staff	$10,000
GRAND TOTAL	$25,000

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. United States

1. Colorado State University: As the US lead institution, this university supports the project's research program. During Dr.

C. J. deMooy's TDY in June/July 1984 at CSU, it was decided that CSU will develop a breeding program for resistance to low night temperatures in cowpeas. Arrangements were made with Dr. D. Wood, on-campus representative of the project, to initiate this support program. Dr. W. Keim, Head of the Department of Agronomy, serves as on-campus administrator. The department also provides on-campus advisers for the two Botswana graduate students who are spending one year at CSU to complete academic coursework required for a Master's degree.

2. Michigan State University: The Bean/Cowpea CRSP MO provides administrative support and backstopping services. A two-week TDY by Dr. C. J. deMooy to the CRSP MO during August 1984 was utilized for exchange of ideas and writing of several articles summarizing project research. The Department of Crop and Soil Sciences at MSU is in charge of the M.S. degree program of a US graduate student. Ms. B. E.deMooy completed her thesis research in Botswana under sponsorship of the project.

3. University of California, Riverside: Dr. C. J. deMooy and Ms. B. E. deMooy visited Dr. Anthony Hall, US Principal Investigator (PI) of the Senegal/University of California, Riverside Bean/Cowpea CRSP project during July 1984 for discussion of cowpea research in Africa. This project and the Botswana project deal with drought problems. Dr. Hall made seeds available from thirty-one lines of cowpea breeding material. Contact between the two projects was continued during a meeting with Dr. Hall at Bambey, Senegal, during September 1984.

4. Kansas State University (KSU): Dr. C. J. deMooy presented a seminar on research findings and scope of the Botswana cowpea project at KSU in August 1984. KSU is the US lead university of ATIP, a farming systems research project located in Botswana. Results obtained by the two projects must be integrated in recommendations made for the agricultural development of the country.

5. US Peace Corps: Assignment of a Peace Corps volunteer to the Botswana Legume Improvement Project of the Department of Agriculture Research has enabled the project to conduct a research program that is more likely to be useful to farmers than would otherwise have been the case. The Peace Corps also contributed by supplying low volume handsprayers to farmers cooperating with the insect control trial program launched by the DAFS and the project.

6. US Plant Introduction Center, Beltsville, Maryland: Communication with the US Plant Introduction Center was continued by mutual exchange of germplasm resources.

B. Botswana: The linkages established during FY 83 were further developed.

1. A collaborative program was established with the Department of Agriculture Field Services. Thirty extension personnel participated, each conducting variety/spraying trials with cooperating farmers in their respective districts. The tests provided much needed information and suggestions for improvement.

   The department changed directors in July 1984. The new director, Mr. T. Taukobong, expressed interest in continuing the joint program. More than 45 extension agents from the Northern, Gaborone and Southern regions will be cooperating during the 1984/85 season along lines developed in joint meetings as a result of FY 83 findings. The program will be more diversified than that of the previous year.

2. Very useful information was gained through cooperation with the Integrated Farming Pilot Project (IFPP). Eighteen field trials were completed and two minimum-tillage planters tested in the field. The IFPP will be terminated as a British-supported farming systems project during 1985, but the joint program will continue under management by the DAFS.

3. Collaboration with EFSAIP was very fruitful. Four variety/-spraying field trials were completed. The two minimum tillage planters were tested in the field at Sebele and modifications were suggested for next year. EFSAIP ceased to exist as a farming systems project, but both cooperators, Messrs. C. R. Riches and D. Horspool, have joined DAR as regular staff, and collaboration will continue as before. Mr. Riches will also continue research on the parasitic weed Alectra vogelii.

4. ATIP contributed by conducting cowpea benchmark surveys in the Francistown and Mahalapye areas which provided the project with very useful baseline information. ATIP utilized the forty dual-purpose cowpea lines provided by the project. Further materials will be supplied to ATIP and seed sources increased as necessary. Prototypes of planters, developed to date by the project, will be made available to ATIP research staff if desired.

5. The Mahalapye Development Trust (MDT) conducted three variety/-spraying trials as part of the nationwide collaborative field program. MDT also increased the seed supply of introduced varieties which the project requested.

6. Cooperation with IITA, Ibadan, Nigeria, continued as before. Dr. B. B. Singh, cowpea breeder of the Grain Legume Improvement Program (GLIP), visited Botswana and Dr. C. J. deMooy visited IITA. Seed resources were exchanged. IITA assisted the project with breeding activities. F_3 generation seed resulting from the crosses made by Dr. B. B. Singh at IITA arrived for field screening in Botswana. IITA also provided the entomology consultant, Dr. L. Jackai, requested by the project in January 1984.

7. Cooperation with SAFGRAD in Burkina Faso continued. Cowpea varieties distributed by SAFGRAD for evaluation were tested under Botswana conditions. Dr. Vas Aggarwal of SAFGRAD contributed

by making special crosses between selected Botswana germplasm and high yielding varieties from his region. F_2 generation seed resulting from these crosses is being evaluated in Botswana.

8. First contact was established with Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) at Goiania, Brazil, where three Bean/Cowpea CRSP projects are located. Besides the insight provided on insect pathogen applications for cowpeas developed by the Brazil/Boyce Thompson Institute Bean/Cowpea CRSP project, EMBRAPA has significant research programs in cowpea drought resistance screening and plant pathology. Exchange of seed and resistance sources between the two countries was arranged through a visit by Dr. C. J. deMooy and Ms. B. E. deMooy to EMBRAPA in June 1984.

9. Periodic contacts were maintained with the Centre National de Recherches Agronomiques (CNRA), Bambey, Senegal. After the visit by Dr. M. Ndoye to Botswana during FY 83, Dr. C. J. deMooy visited CNRA in September 1984 to exchange ideas concerning field problems, procedures and varieties.

10. The Baptist Mission, Maun, Botswana continued to receive seed shipments from the project in support of their efforts to estimate cowpea growing in northern Botswana.

XII. FY 85 PROPOSED PLAN OF WORK

No changes are anticipated in project objectives and rationale. The Botswana institution supports the project's work program. Some expansion is envisaged in breeding new varieties based on local germplasm incorporating desirable traits from exotic material such as multiple insect and disease resistance and high yield capacity. Also a more precise identification of virus infections and degree of disease and insect resistance would be desirable.

Temporary appointments of a legume pathologist/breeder (50 percent) and legume entomologist (25 percent) will assist in establishing the intended emphasis. Recent changes in project personnel included transfer of Ms. B. E. deMooy to MSU in August 1984 for completion of M.S. degree requirements. Ms. deMooy's return travel to Botswana is anticipated in June 1985. Ms. Karen Conniff joined the field staff in Botswana in September 1984 for dissertation research. Two Botswana students will return from CSU during the next year to commence thesis research leading to the M.S. degree. Mr. P. Montshiwa will arrive in December 1984 and Ms. M. Manthe in September 1985.

A. United States: Supportive research on low night temperature resistance breeding at CSU is in the planning stage.

B. Botswana: Experiments are planned in the areas of germplasm evaluation, general evaluation of USDA cowpea materials, screening of new cowpea lines from IITA and SAFGRAD. Also anticipated are variety adaptation trials, evaluation of F_3 and F_5 breeding materials derived from Botswana germplasm x exotic crosses and

estimation of percentage of natural outcrossing in cowpeas at various plant populations under Botswanan environmental conditions. Intercropping, cultural practices, moisture conservation, nodulation evaluation, soil fertility and integrated cowpea pest control trials will also be carried out. Appropriate tests in farmers' fields will be conducted.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

deMooy, B. E. In press. Variability of Characteristics of Botswana Cowpea Germplasm. Tropical Grain Legume Bulletin, IITA, Ibadan, Nigeria.

_____. In press. Cowpea Germplasm Collecting in Botswana. Plant Genetics Resources Newsletter, FAO, Rome.

_____. 1984. Botswana Cowpea Germplasm Catalogue (Vigna unguiculata [L] Walp.), Vol. 1. Gaborone, Botswana: Ministry of Agriculture.

_____. 1984. Botswana Cowpea Germplasm Catalogue (Vigna unguiculata [L] Walp.), Vol. 2. Gaborone, Botswana: Ministry of Agriculture.

deMooy, C. J. In press. Search for More Suitable Cowpea Varieties for Semiarid Conditions in Botswana. Research Highlights II(1). East Lansing, MI: Michigan State University, Bean/Cowpea CRSP Management Office.

_____. In press. The Development of More Appropriate Cultural Practices and Agricultural Implements for Cowpea Production in Semiarid Botswana. Research Highlights. East Lansing, MI: Michigan State University, Bean/Cowpea CRSP Management Office.

_____. 1984. Early Maturing Cowpea Varieties. Paper presented at Department of Agricultural Field Services, Gaborone Region Meeting, Sebele, Botswana, February 27-29, 1984.

_____. 1984. Variety Trials for Botswana. Paper presented at Department of Agricultural Field Services, Southern Region Meeting, Pelotshetlha, Botswana, May 21-25, 1984.

_____. 1984. The Bean/Cowpea CRSP in Botswana. Seminar for the Department of Agronomy, Kansas State University, Manhattan, KS, August 24, 1984.

USAID. 1984. The Cowpea CRSP Program in Botswana. Presentation in US Economic Assistance to Africa Film produced by AID/Washington.

BRAZIL • BOYCE THOMPSON INSTITUTE

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, US Department of Agriculture (USDA), BTI
Postdoctoral Associate:	Dr. Stephen P. Wraight, IPRC, BTI
Research Assistants:	Mr. James Wenban, Biological Control Program, BTI
Laboratory Assistant:	Ms. Claudia Orr, Biological Control Program, BTI
Financial Officer:	Mr. John Dentes, Treasurer, BTI
Institutional Representative:	Dr. Edwin Oyer, Director, International Agriculture Program, Cornell University

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

Principal Investigator:	Mr. Bonifacio P. Magalhães, Centro Nacional de Pesquisa de Arroz e Feijão (CNPAF), EMBRAPA
Collaborator:	Mr. Massaru Yokoyama, CNPAF, EMBRAPA
Consultants:	Mr. Belmiro Pereira das Neves, CNPAF, EMBRAPA
	Dr. Evane Ferreira, CNPAF, EMBRAPA
US Research Associate:	Dr. Richard A. Daoust, CNPAF, EMBRAPA
Laboratory Assistants:	Mr. Sabastiao M. dos Santos, CNPAF, EMBRAPA
	Ms. Laila H. Mihsfelt, CNPAF, EMBRAPA
	Ms. Heloisa da Silva Coelho, CNPAF, EMBRAPA
	Ms. Filiane da Silva Coehlo, CNPAF, EMBRAPA
	Ms. Janine Ribeiro Silva, CNPAF, EMBRAPA
Administrative Advisor:	Dr. Almiro Blumenschein, Director, EMBRAPA

C. USAID Project Officer: Mr. Howard Lusk, US Embassy, Brasilia, Brazil

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives

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

2. 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.

B. FY 84 Objectives: See V below.

III. CHANGES IN OBJECTIVES: None.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Technical difficulties include the labor-intensive and time-consuming nature of laboratory insect rearing. Some species have proved difficult to recycle in the laboratory. Good progress was made, however, with other pest species, as mentioned below (V.3). Many insects found in Latin American cowpea fields have not been unequivocably identified; and their life histories, distributions and relative importance as pests are poorly documented. This has ramifications in the development of pest-control strategies. (The literature on cowpea insect pests, including informally published research reports, is being gathered for presentation to cowpea researchers as a review published in collaboration with an IITA scientist and as a paper delivered to an international meeting on cowpeas.) Adequate basic information is also lacking on conditions appropriate to initiating epizootics in the field. This is recognized as one of the project's major research areas, and studies are underway.

B. Since the project's beginning, a major hindrance to research in Brazil has been the difficulty in importing equipment and supplies. Equipment purchases within Brazil generally were not permitted with AID funds. Therefore, equipment importation was required. Import permits, however, were granted slowly or not at all even though the items were to be donated to EMBRAPA prior to shipping from the US. Nevertheless, through a combination of hard work on the part of some Brazilian authorities, patience and good fortune, a significant number of items were imported between 1982 and 1984. There was no consistent system for importation. The Brazilian government

instituted a policy in 1984 to permit importation without license of shipments valued at less than $3,000. This system was tested and found workable in mid-1984. Accordingly, future importation of small equipment should be facilitated. Since USAID did not act upon requests for equipment budgeted for FY 84, the items could not be purchased. Only equipment requested and approved in earlier years but delayed because of Brazilian importation problems was obtained in 1984.

C. Until early 1984, Dr. Almiro Blumenschein, the Director of CNPAF, served as Host Country Principal Investigator (PI) and principal administrator. This was necessary because EMBRAPA had no permanent employees engaged in insect pathology at CNPAF. As noted elsewhere in this report, the project was conducting considerable training of potential EMBRAPA insect pathologists. Nevertheless, in January 1984 the Bean/Cowpea CRSP External Review Panel recommended that a HC PI active in research be appointed as soon as possible to facilitate project institutionalization. Accordingly, a CNPAF entomologist, Mr. Bonifacio P. Magalhães, was appointed by Dr. Blumenschein as HC PI. Mr. Magalhães is very interested in insect pathology/microbial control and plans to make this his major research activity. He completed a one-month study period at BTI in 1984.

V. PROGRESS TOWARD OBJECTIVES

The FY 84 project objectives and results were as follows:

A. Continue Development of an Insect Pathology Unit in Brazil: Many new isolates of entomopathogenic fungi and bacteria were added to the microorganism repositories in Brazil, and US training materials on the microbiological control of cowpea pests were developed and translated into Portuguese. The literature repository was increased, and supplies and equipment valued at over $15,000 were imported from the US during 1984.

B. Extend Surveys for Pathogens of Cowpea and Bean Pests: Survey trips to cooperatives, research centers, universities and local bean and cowpea farmers were made. Many of these were to areas of Brazil not previously visited, including the states of São Paulo, Paraná, Santa Catarina, Rio Grande do Sul, Rondonia, Acre, Amazonas, Goías (north of Goiañia), Alagoas and new parts of Pernambuco and Paranaiba. More than fifty new pathogen isolates were discovered in 1984.

C. Commence Graduate Degree Training in Brazilian and US Universities and Non-Degree Training at CNPAF and BTI: The training program was very active. See VII below.

D. Continue Development of Laboratory Colonies of Cowpea Pests: Considerable progress was made in the establishment of cowpea pest colonies in Brazil including Empoasca kraemeri, Cerotoma arcuata, Chalcodermus aeneus, Elasmopalpus lignosellus, Spodoptera spp. and two predatory species, Coleomegilla maculata and Eriopis conexa, found in cowpea fields.

E. Continue Screening and Development of Biological Assays of Entomopathogenic Fungi and Bacteria Against Cowpea Pests: Entomopathogenic fungi in the genera Erynia, Beauveria, Metarhizium, Paecilomyces, Nomuraea and Hirsutella were tested against cowpea pests. Several of these were highly pathogenic to Elasmopalpus lignosellus, Chalcodermus aeneus, Cerotoma arcuata and Empoasca kraemeri. Fungi were less promising as control agents against Spodoptera spp. Tests with entomopathogenic bacteria were initiated against C. arcuata. Dosage-mortality bioassays were conducted against C. aeneus, C. arcuata and E. kraemeri with insect pathogenic fungi. Empoasca fabae (US) was proved similarly susceptible to Erynia radicans as Empoasca kraemeri (Brazil).

F. Commence Gathering Information on the Ecology and Epizootiology of Mycoses of Cowpea Pests: Field experiments to study the epizootiology of E. radicans on E. kraemeri were carried out in Brazil. Studies were conducted on the stability of the entomopathogenic fungus Beauveria bassiana on natural hosts and on taiuia under field conditions. It was demonstrated that the fungus can remain viable under field conditions, if protected from the sun and rain, for more than thirty-two weeks. Tests to determine the safety of fungi to beneficial insects in cowpea fields were initiated. Both E. radicans and B. bassiana were non-pathogenic to insect-predatory species (Coleomegilla maculata and Eriopis conexa) but were highly pathogenic to pest insects (E. kraemeri and Cerotoma sp.) in bioassays.

G. Conduct Screenhouse and Field Trials with Insect Pathogens: Screenhouse and field trials were conducted at CNPAF and in northern Brazil with B. bassiana strain CP 5 against chrysomelid beetles. Results were promising for both foliar applications and for the use of the chrysomelid beetle-attracting root, Cayaponia tayuya. Diabrotica speciosa and Cerotoma arcuata were highly susceptible to B. bassiana under these conditions. Field tests of Hirsutella guyana, Erynia radicans and Metarhizium anisopliae against caged populations of Empoasca kraemeri were unsuccessful, producing less than 10 percent mortality. These results were attributed to the dry, cool conditions which prevailed in the field at the time of the tests (mid-July).

H. Continue Research on Small-Scale Production and Formulation of Selected Pathogens (For Use in Field Trials): A method developed for production of a dry, powder formulation of Erynia radicans (see Bean/Cowpea CRSP 1983 Annual Report: Technical Summary) was successfully applied to an isolate of Hirsutella guyana from Empoasca kraemeri.

VI. RESEARCH OUTPUTS

A. Available for Immediate Use

1. The survey for insect-disease agents in Brazilian pests of cowpea and other legumes has provided more than 150 fungal isolates to the scientific community. Some of these were

distributed to interested Brazilian, US and other scientists fc 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 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 them to request collaborative research and to provide diseased specimens. This increase in interest and knowledge in insect pathology will enhance the chances of success for Brazilian microbial control projects.

B. Available for Use Within One to Two 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 studies worldwide.

3. Formal (degree) training of Brazilian scientists will significantly increase the expertise available in that nation in insect pathology and microbial control of insect pests.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Suppor
US Citizens:						
Wraight	F	Cornell	Entomology	Ph.D.		Total
Brazil Citizens:						
de Lima	F	ESAL*	Plant Protec.	M.S.		Total
Quintela	F	ESALQ**	Entomology	M.S.		Total
Fernandes	M	ESALQ**	Entomology	M.S.		Total
Others:						
None						

*Escola Superior de Agricultura de Lavras
**Escola Superior de Agricultura de Luiz Queiroz

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
None					
Brazil Citizens:					
Pereira	M	CNPAF	Research Intern.	CNPAF	9 months
de Lima	F	CNPAF	Research Intern.	CNPAF	14 months
Fernandes	M	CNPAF	Research Intern.	CNPAF	8 months
Magalhães	M	CNPAF	Research Intern.	BTI	5 weeks
Nine females and eleven males		*	Training Course	CNPAF	1 week
Ten males		**	Training Course	CNPAF	1 day
Fourteen females and eleven males		***	Summer Interns Training Course	CNPAF	1 day
Others:					
Camarena	F	Mexico	Short-term Intn.	CNPAF	3 weeks

During FY 84, a week-long lecture and laboratory course on insect pathology and microbial control was offered at CNPAF for twenty scientists. All held B.S., M.S. or Ph.D. degrees. Nine were women, including a scientist from Mexico. In addition, thirty-five Brazilian scientists, twenty-one men and fourteen women, received one-day training at CNPAF as part of other CNPAF training programs. Three long-term (three months or longer) research internships were sponsored and directed by the project at CNPAF. Two men and one woman participated. The Brazilian PI spent five weeks in the US studying insect pathology concepts and techniques. Four CRSP-supported scientists, one man and three women, started degree programs in two Brazilian and one US university. The three Brazilians will conduct research under project direction at CNPAF. M.S. degree training of a Brazilian in the US has been arranged for 1985.

VIII. BASELINE DATA

Cowpea production in Brazil is extremely variable. Large producers (100 hectares or more) exist, but much smaller holdings are the norm. Virtually all cowpeas on small holdings are intercropped 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 most are used as dried beans. Consumers of dried cowpeas show regional differences regarding acceptable color, size and taste and, therefore, utilize different cowpea lines.

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*Second Training Course on the Microbiological Control of Cowpea Pests with participants from eleven Brazilian states and one from Mexico.
**Second Course on the Production of Cowpeas with participants from throughout Brazil.
***Summer interns--participants from throughout Brazil.

With such variability in cropping patterns, it is difficult for a project with limited funds and expertise in social sciences and economics to gather baseline data. The specific area(s) where microbial control agents may be utilized on a wide-scale basis needs to be identified before gathering data. 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 works with the Brazilian National Cowpea Improvement Program. To date, Dr. Watt and the project personnel's informal observations made during survey trips have served as information sources. Should more detailed information be required, the project should be expanded to employ properly qualified specialists.

In FY 84, project staff made visits to various locations in Brazil where entomopathogenic fungi are produced and used in pasture and sugarcane. This represented an effort to estimate the level of growers' acceptance of new technology such as the use of insect diseases for pest control. Although not quantifiable, this group's enthusiasm indicates high acceptance by Brazilian administrators and farmers.

IX. WOMEN IN DEVELOPMENT

From its inception, the project has had significant participation by women. This is particularly true in the training area. Almost half of those trained by the project in Brazil are women and the project's only degree candidate in the United States is a woman. For details see section VII.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States: The BTI administrative officers have been very supportive of the project since its inception and have encouraged enthusiastic pursuit of its goals. Accountable financial support from BTI is expected to be $75,383 in FY 84 distributed as follows:

1.	Personnel	$31,243
2.	Materials and supplies	$989
3.	Other direct costs	$1,702
4.	Travel	$655
5.	Indirect costs and facilities	$40,794

The fungal isolates collected in Brazil have been maintained by the USDA group at BTI headed by Co-PI, Dr. R. Soper, and identification of the fungal specimens was done by Dr. R. Humber of the USDA group. Although their monies are federal and, therefore, not applicable as matching funds for the grant, several months of salary from USDA base funds were expended in the support of this project.

B. Brazil: The EMBRAPA administration, including the President, Dr. Eliseu Alves, and the CNPAF Director, Dr. Almiro Blumenschein, has been supportive of the collaborative project. Dr. Blumenschein has

been particularly interested in insect pathology training at CNPAF and in encouraging collaborative research between CNPAF scientists and the CRSP research associate at CNPAF. Extensive collaborative efforts are now under way. 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.

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. As a result of the project's extensive survey, collaborative research and teaching activities in Brazil, the staff has had significant interactions with more than thirty university and state and federal government groups located in virtually all cowpea-growing areas of the country. These interactions have been very productive and cordial, and extensive exchanges of materials, ideas and personnel are expected in future years.

B. Productive training affiliations were instituted with two Brazilian universities in 1984. The universities are providing courses to three CRSP-supported M.S. students. The M.S. theses will be done at CNPAF with the CRSP project's research associate as advisor. The students will receive degrees from these universities: Escola Superior de Agricultura de Lavras, Lavras, Minas Gerais, and Escola Superior de Agricultura de Luiz Queiroz, Universidade de Sao Paulo, Piracicaba, S.P.

C. The principal international center interaction was between Dr. N. Jackai of IITA and Dr. R. A. Daoust of BTI (Brazil) who began a joint review article on insect pests of cowpeas.

XII. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy

1. Surveys: The search for new and/or more virulent strains of entomopathogens will continue through surveys in Brazil. Surveys, however, will be emphasized less in 1985 in order to accelerate research activities at CNPAF and with collaborators in northern Brazil and to devote more time to training graduate students and interns at CNPAF.

2. Bioassays and insect rearing: Major emphasis will be placed on improving the rearing facility and training staff in the laboratory culture of cowpea and bean pests in Brazil. Techniques to more efficiently rear cowpea pests will be emphasized. Laboratory screening of fungal and bacterial pathogens will continue in Brazil and the US.

3. Epizootiological and field studies with entomopathogens: Epizootiological studies will be continued to gather baseline data on the physical and biological factors effecting disease incidence of major pests in Brazil and the US in the field and laboratory. Empoasca and chrysomelid leaf-feeding beetles will

be emphasized. Research will continue in the screenhouse and field at CNPAF and in the Amazonas state to develop B. bassiana for chrysomelid beetle control. Studies will also continue on pathogen stability in the field and the laboratory under controlled conditions and on the safety of pathogens to natural enemies of cowpea pests.

B. Training Objectives and Strategy

1. In 1985, training in insect pathology and microbial control in Brazil will continue as a major priority. A one-week course will be offered on bean and cowpea entomology in cooperation with CNPAF. Training of B.S. level research interns will continue in Brazil.

2. Three Brazilian graduate students (M.S.) in two Brazilian universities will begin thesis work in Goiañia. Another Brazilian will begin graduate study at Cornell University in January 1985. A US graduate student (Ph.D.) will commence field research on the epizootiology of Erynia in Empoasca populations.

3. Short-term internships for Brazilians will also continue at CNPAF and at BTI. In this regard, it is expected that the Brazilian PI will visit the US in 1985 for continued training.

4. On-site training of cowpea scientists in northern and northeastern Brazil and exchange of information with Brazilian colleagues will continue through discussions, exchange of pathogen cultures, collaborative research and visits.

C. Anticipated Personnel/Location Changes: After serving a productive three-and-one-half years as research associate for the project in Brazil, Dr. Richard A. Daoust will return to the US in March 1985. Dr. Jeffrey C. Lord, an insect pathologist trained at the University of Florida, Gainesville, will replace Dr. Daoust in Brazil after a short overlap period. The project will continue to be centered at CNPAF.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Anderson, T. E. and D. W. Roberts. 1983. Compatibility and Use of Beauveria bassiana--Insecticide Combinations. XVI Annual Meeting Society for Invertebrate Pathology, Cornell University, Ithaca, NY, August 7-11, 1983; pp. 29,32 (Abstract).

Cai, B.-L., D. W. Roberts and R. A. Humber. 1984. Biological Characterization of Erynia delphacis Isolates from the South of People's Republic of China. XVII Annual Meeting Society for Invertebrate Pathology, University of California, Davis, CA, August 5-9, 1984; p. 26 (Abstract).

Daoust, R. A. 1984. Conducting Insect Pathology/Microbial Control Short Courses. Workshop Keynote Speaker at the XVII Annual Meeting Society for Invertebrate Pathology, University of California, Davis, CA, August 5-9, 1984.

Daoust, R. A., P. M. Fernandes, B. P. Magalhães and M. Yokoyama. 1984. Pathogenicity of Beauveria bassiana Applied to Cowpea Foliage and Curcubitacid Tubers, Cayaponia sp., to Adult Diabrotica speciosa and Cerotoma sp. (Coleoptera: Chrysomelidae) in Brazil. XVII Annual Meeting Society for Invertebrate Pathology, University of California, Davis, CA, August 5-9, 1984; pp. 40-41 (Abstract).

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BRAZIL • UNIVERSITY OF WISCONSIN

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 of Horticulture, UW
Co-Principal Investigator:	Dr. Frank Dazzo, Department of Microbiology and Public Health, Michigan State University (MSU)
Contract Officer:	Ms. Barb Keenan, UW
Institutional Representative:	Dr. Richard L. Lower, Assistant Dean, College of Agricultural and Life Sciences, UW

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

Principal Investigator:	Mr. Ricardo Silva Araujo, Centro Nacional de Pesquisa de Arroz e Feijão (CNPAF), EMBRAPA
US Research Associate:	Dr. Robert Henson, CNPAF, EMBRAPA
Field Technician:	Mr. Abdala F. Borges, CNPAF, EMBRAPA
Field Staff:	Mr. Helio Dionizio de Rezenda, CNPAF, EMBRAPA
	Mr. Trago Monteiro Damascino, CNPAF, EMBRAPA
Laboratory Technicians:	Mr. Carlos A. Cavalcante, CNPAF, EMBRAPA
	Mr. Alfonso Celso da Costa, CNPAF, EMBRAPA
Laboratory Auxiliary:	Mr. Aldimar Ferreira dos Santos, CNPAF, EMBRAPA
General Auxiliary:	Mr. Bob Aliso Renascenca, CNPAF, EMBRAPA
Scholarship Student (Bolsista):	Ms. Lilian F. da Cunha, CNPAF, EMBRAPA
Administrative Advisor:	Dr. Almiro Blumenschein, Chief CNPAF, EMBRAPA

C. USAID Project Officer: Mr. Howard Lusk, US Embassy, Brasilia, Brazil

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives: Develop superior common bean cultivars capable of enhanced biological nitrogen fixation (BNF) that, in association with superior strains of Rhizobium phaseoli, produce high yields under bean monoculture and intercropping systems without supplemental nitrogen fertilizer.

B. FY 84 Objectives

1. Research

a. Plant improvement through selection

(1) Assess in field accessions and breeding populations for N_2 fixation.

(2) Develop additional populations segregating for high N_2 fixation.

b. Rhizobium collection and evaluation

(1) Develop methods for enumerating rhizobia from field soil.

(2) Evaluate selected R. phaseoli strains for effectiveness.

(3) Produce rifampicin-resistant strains of R. phaseoli for field ecological studies.

c. Study of factors affecting N_2 fixation

(1) Quantify N_2 fixation of beans grown in monoculture and corn/bean relay.

(2) Investigate differences in N_2 fixation relative to cropping systems.

d. Dissemination of plant materials and scientific information

(1) Provide selected bean lines to national programs, Bean/Cowpea CRSP projects and US scientists.

(2) Provide information on methods and techniques for quantifying soil rhizobia, selecting superior competitive strains of R. phaseoli and selecting bean lines for enhanced N_2 fixation.

2. Training

a. Provide M.S. degree training in plant breeding and plant genetics at UW.

b. Provide advanced-level non-degree training in rhizobiology at MSU.

III. CHANGE IN FY 84 OBJECTIVES: None.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Technical: Accurate direct estimation of actual amounts of N_2 fixed under field conditions is difficult to obtain for large populations of plant families.

B. Administrative: Difficulty was experienced in spending funds in Brazil at the anticipated level. Insufficient funds were available for purchase of small items. The budget for FY 84 was not approved until August 15, 1984.

C. Human: Mr. Ricardo Silva Araujo, the Host Country (HC) Principal Investigator (PI) working on rhizobiology could stay at MSU for only three months to pursue studies of the basis for enhanced nodulation of beans grown in relay compared to monoculture.

D. Physical-logistical: The planned purchase of equipment by UW to be donated to CNPAF was not possible. There are too few research vehicles at CNPAF. Permission to purchase an alcohol-fueled truck in Brazil was requested six months ago.

V. PROGRESS TOWARD OBJECTIVES

A. Training: Graduate degree training in plant breeding and plant genetics was provided for two M.S. degree candidates. Both attended the MSTAT computer workshop at MSU and one completed a tour of US bean research projects.

B. Research

1. Plant improvement through selection: A three-stage procedure for field-testing was used to assess N_2 fixation potential of black bean and colored bean lines. Some sixty inbred backcross lines of WI Pop. 22 were evaluated at CNPAF and also at UW. Thirteen lines were chosen for further testing and five lines (22-3, 22-8, 22-24, 22-34 and 22-50) for elite evaluation trials. Six lines were provided to Dr. Thung for the CIAT preliminary yield trials. Selection 22-34 was used extensively in experiments, including the on-farm trials in Brazil, the CNPAF rust screening and CIAT's screening for response to low phosphorus. The best selections compared favorably to the CIAT line BAT 76.

   Four colored-bean lines--Honduras, Lustroso, F. V. Roxa and IPA 1--were promising.

   Three populations of inbred backcross lines--Goiañia Precoce, carioca and rosinha seed types--were evaluated at UW. Other populations are being developed in cooperation with Dr. María José Zimmermann at CNPAF.

2. Rhizobium collection and evaluation: The R. phaseoli strains evaluated under controlled conditions for nodulation and N_2 fixation at MSU and found to be the most effective were CNPAF

150, CIAT 632, CIAT 640, 127K81-3, KIM-5, MG336, J033 and J034. For interstrain competition studies, the ineffective R. phaseoli strains isolated were: J025, J029 and J031.

Rifampicin resistant strains were produced for use in field ecological studies at CNPAF. Mutants that fixed nearly as well as the wild type included 150 (R4), 189 (R1), 189 (R4), 189 (R5) and KIM-5 (R3).

Improved methods to enumerate bean rhizobia from soil were developed. The most common method, the plant infection count using the most probable number (MPN) technique in Leonard jars, is open to microbial contamination. A tube culture MPN technique was developed to overcome this problem.

Network experiments were conducted at several locations in Brazil to identify the best R. phaseoli strains on a standard set of common bean lines.

3. Evaluation of factors affecting N_2 fixation under field and controlled environment conditions: Experiments were conducted in the field and glasshouse to evaluate the effects of genotype and plant growth stage on nodulation characteristics. All genotypes had fewer nodules, less nodule dry weight and lower total acetylene reduction (AR) in the field than in the glasshouse; but specific nodule activities were similar. The standard cultivar, Rio Tibagi, produced fewer nodules than Negro Argel and WI 22-34.

   Beans grown in monoculture showed different amounts of nodulation compared to beans grown in relay with maize. Treatments containing maize roots and stalks favored production of more nodules. Bean roots from plants grown in these experiments are being examined for endomycorrhizae, using new methods for fixing and clearing roots.

   Experiments were conducted at UW to identify bean lines that grow well at low P levels. Factors considered were three bean genotypes and comparison of fertilizer N vs N derived from N_2 fixation. Differences in total dry matter were similar for each genotype regardless of N source. Nodule dry weight and nodule number were positively correlated with P level, and relative differences between genotypes were maintained over the range of P from 50 to 400 mM (loading concentration on activated alumina).

   Beans alley-cropped between rows of Leucaena showed no reduced production per unit of land area. The benefits from Leucaena would still be realized.

4. Dissemination of plant materials and scientific information: Promising black bean breeding lines were provided to other programs at CNPAF, including the on-farm trials, network experiments throughout Brazil, phosphorus evaluation trials of

CIAT at CNPAF, preliminary yield trials of CIAT and the disease resistance Bean/Cowpea CRSP project at CNPAF. Selected breeding lines have been provided to other Bean/Cowpea CRSP projects and to US scientists.

Dissemination of scientific information has been through participation of project personnel in scientific meetings, workshops and training sessions.

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use

1. Black bean lines with genetic potential to fix high levels of N_2 have been developed: lines 22-3, 22-8, 22-24, 22-34 and 22-50.

2. Breeding and selection methods exist that are suitable for use in bean improvement programs that include enhancement of N_2 fixation.

3. Strains of Rhizobium phaseoli were developed having high N_2 fixing ability under controlled conditions: Kim-5, CIAT 632, CIAT 640, 127K81-3, MG 336, J033, J035 and CNPAF 150.

B. Available Within One to Two Years

1. Information will be gathered about bean production and utilization on farms in Brazil.

2. Breeding lines of important market classes, e.g. Goiania Precoce, black, carioca, rosinha will be developed with genetic potential to fix high levels of N_2 when grown in prevailing production systems.

3. Information will be published describing effective breeding procedures and selection methods for increasing the N_2 fixation potential of common bean will be delineated.

4. Features of mixed cropping and monoculture systems that either enhance or decrease the N_2 fixation of beans.

5. Rabbit antisera will be developed against sonicated cells of R. phaseoli Kim-5 strain.

6. Highly competitive, ineffective strains of bean rhizobia indigenous to Brazil will be sought.

7. Strains of bean rhizobia that effectively nodulate bean lines in competition with ineffective indigenous strains will be sought.

8. An account of improved methods for enumerating bean rhizobia by the MPN technique under microbiologically controlled conditions will be published.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	Degree University	CRSP Department	Degree	Date Received	Support
US Citizens:						
None						
Brazil Citizens:						
Pereira	M	UW	Horticulture	M.S.		None
Others:						
Nchimbi	F	UW	Horticulture	M.S.		Total

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
None					
Brazil Citizens:					
Araujo	M	CNPAF	Adv. trng. rhizo. tech.	MSU	Three mo.
Pereira	M	CNPAF	MSTAT Wkshp.	MSU	One week
da Cunha	F	CNPAF	Adv. trng. N_2 fix.	CNPAF	One year
Other:					
Flores	M	Mexico	Trng. in rhizo. tech.	MSU	Six months
Mloza-Banda	M	Malawi	Same	MSU	Three mo.
Nchimbi	F	Tanzania	MSTAT Wkshp.	MSU	One week

Mr. Araujo and Dr. Bob Henson presented a half-day lecture and gave laboratory demonstrations on N_2 fixation at CNPAF.

VIII. BASELINE DATA

A. Bean production and utilization data are being acquired through the farming system survey at CNPAF.

B. The N_2 fixation potential of Brazilian landrace cultivars and commonly-grown introduced cultivars is being obtained.

C. Brazilian landrace cultivars grown by farmers are being collected and evaluated at CNPAF.

D. Superior introduced and indigenous strains of *R. phaseoli* are being evaluated in network trials.

E. Isolates of *R. phaseoli* are being collected from cultivars and bean selections growing in Brazil to determine the competitiveness and effectiveness of native rhizobia.

IX. WOMEN IN DEVELOPMENT

A. United States: Ms. Susan Nchimbi (supported by Tanzania/Washington State University Bean/Cowpea CRSP project), is pursuing an M.S. degree in plant breeding and plant genetics at UW. Her research will have direct relevance to women's roles in Tanzania.

B. Brazil: Ms. Lilian Ferro da Cunha (B.S. degree in agronomy from the Rural Federal University at Rio de Janeiro) has received a one-year scholarship for training in bean research at CNPAF.

The breeding program of Dr. María José Zimmermann at CNPAF includes collaborative studies with this project.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States

1. Personnel

Dr. F. A. Bliss, professor, UW, Madison, 20 percent, $7850
Dr. Frank Dazzo, associate professor, MSU, 5 percent, $2370

2. Student training: None.

3. Facilities

MSU: Two research labs (878 + 1500 square feet)
UW: Three research labs (2000 square feet), two student desks, greenhouse space (200 square feet), experimental field at the Arlington horticulture farm and the Hancock experiment station, use of travel van.

4. Materials and supplies: Paid for by CRSP funds.

5. Travel: Paid for by CRSP funds.

B. Brazil

1. Personnel

Dr. Ricardo Silva Araujo, rhizobiologist, CNPAF
Mr. Helio Dionizio de Rezende, field staff
Mr. Thiago Monteiro Damasceno, field staff
Mr. Carlos Alberto Cavalcante (until 3/84), lab technician
Mr. Alfonso Celso da Costa (since 6/84), lab technician
Mr. Aldimar Ferreira dos Santos, lab auxiliary
Mr. Bob Aliso Renascenca, general auxiliary

2. Student training

Mr. Pedro Pereira, research assistant, approximate value $15,000

Ms. Lillian Ferro da Cunha, bolsista

3. Facilities: Research labs, offices, greenhouse space, field plots at CNPAF, Goiañia, Goías.

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages

1. United States

   a. Michigan State University: Dr. F. Dazzo serves on the degree committee of Ms. Catalina Samper, a graduate student on the Mexico/MSU Bean/Cowpea CRSP project.

      Mr. Henry Mloza-Banda, a graduate student on the Malawi/MSU Bean/Cowpea CRSP project, received three months training in rhizobiology in Dr. Dazzo's lab.

   b. University of Wisconsin: Mr. N. Wassimi, a student with Dr. G. Hosfield at MSU on the INCAP/Washington State University Bean/Cowpea CRSP project, analyzed 1200 bean flour samples for percentage seed protein at UW.

   c. Sixty black bean lines were screened for rust reaction at CNPAF by the Brazil/UW Bean/Cowpea CRSP disease resistance project.

2. Brazil

   a. Relationships were established with the extension and farming systems groups at CNPAF, EMBRAPA.

   b. Linkages were made with bean researchers at other stations throughout Brazil.

B. On-Going Linkages

1. United States

   a. University of Wisconsin: Research relationships continued with:

      (1) The Honduras/University of Puerto Rico Bean/Cowpea CRSP project.

      (2) The Dominican Republic/University of Puerto Rico and University of Nebraska Bean/Cowpea CRSP projects.

      (3) The Mexico/MSU Bean/Cowpea CRSP project.

2. Brazil: Relationships continued with:

   a. Other Brazilian programs in N_2 fixation, e.g. EMBRAPA Km 47 (Rio de Janeiro), CENA Piracicaba, São Paulo and others.

b. Other bean researchers at CNPAF, EMBRAPA, e.g. Dr. María José Zimmermann, Dr. Josias de Faria and others.

XII. FY 85 PROPOSED WORK PLAN

A. Research Objectives and Strategy

1. Research objectives

a. United States

(1) University of Wisconsin

(a) Administration and coordination of the project.

(b) Mr. Pedro Pereira will continue M.S. thesis research.

(c) Ms. Susan Nchimbi will initiate Ph.D. thesis research.

(d) Data from experiments in Brazil will be compiled and analyzed.

(e) New breeding populations will be developed.

(2) Michigan State University

(a) R. phaseoli strain evaluation for effectiveness N_2 fixation on selected bean lines will be completed.

(b) Competitiveness of selected superior strains against ineffective, competitive indigenous strains will be evaluated.

(c) Total and specific AR activity of nodules formed by KIM-5 strain on standard and selected bean lines will be measured.

(d) The new MPN technique will be further evaluated and the results published in a scientific journal.

b. Brazil--CNPAF

(1) Further evaluation and selection of breeding lines and accessions for superior N_2 fixation with and without N fertilizer are to take place.

(2) Superior selections for testing in on-farm trials, network trials, disease evaluations and intercropping experiments will be provided.

(3) Studies on nodule formation and longevity under different cropping systems with and without maize will be continued.

(4) Amounts of N_2 fixed by advanced selections and standard cultivars using 15 N labeled compounds will be estimated.

2. Research strategy: The strategy is to develop improved bean lines responsive to both native and introduced rhizobia. The most promising lines will be evaluated under cropping systems used in Brazil. Early evaluation of promising lines will be made in on-farm trials. Promising lines will be provided to other projects for wide evaluation.

Selection of competitive R. phaseoli strains on improved bean selections will be made. When superior strains are available, studies will be maue in parallel with the plant evaluations indicated above under prevailing cropping systems in Brazil.

B. Training Objectives and Strategy

1. United States

a. University of Wisconsin: Degree training will be continued for Mr. Pedro Pereira and Ms. Susan Nchimbi.

b. Michigan State University: Non-degree training in rhizobiology will be provided as needed.

2. Brazil--CNPAF

a. A workshop on improving N_2 fixation is planned.

b. Practical training in N_2 fixation for the scholarship student, Ms. Lilian Ferro da Cunha, is anticipated.

D. Anticipated Personnel/Locational Changes: None.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Bliss, Fredrick A. 1984. Breeding for Enhanced Dinitrogen Fixation Potential in Common Bean. In P. Ludden and J. Burris (eds.). Nitrogen Fixation and CO_2 Metabolism. Proceedings of the 14th Steenbock Symposium, June 17-22, 1984. New York: Elsevier Publishing Co.

Henson, R. and R. S. Araujo. 1984. Fixação de N_2 no Sistèma de Substituicão Milho/Feijão. Paper presented III Reunião Nacional de Pesquisa com Feijão (P. vulgaris) em Consorcio. EMCAPA, Cariacica, Espirito Santo, 4-6 June, 1984.

BRAZIL • UNIVERSITY OF WISCONSIN

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. Douglas P. Maxwell, Department of Plant Pathology, UW
Co-Principal Investigator:	Dr. Donald J. Hagedorn, Department of Plant Pathology, UW
Research Associate:	Dr. Debra Ann Inglis, Department of Plant Pathology, UW
Specialist:	Mr. Robert Rand, Department of Plant Pathology, UW
Technical Assistants:	Mr. Eric Carlson, Department of Plant Pathology, UW
	Ms. Jayne Frauenfelder, Department of Plant Pathology, UW
Contract and Grant Officer:	Mr. Robert Erickson, Research Administration, UW
Institutional Representative:	Dr. R. Lower, Assistant Dean, College of Agricultural and Life Sciences, UW

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

Principal Investigator:	Dr. Josias C. de Faria, Centro Nacional de Pesquisa Arroz e Feijão (CNPAF), EMBRAPA
Co-Principal Investigators:	Mr. Aloisio Sartorato, CNPAF, EMBRAPA
	Mr. Carlos A. Rava, CNPAF, EMBRAPA
	Dr. María J. Zimmermann, CNPAF, EMBRAPA
Laboratory Technicians:	Mr. Elcio de Oliveira Alves, CNPAF, EMBRAPA
	Mr. Jackson Marciano, CNPAF, EMBRAPA
	Mr. S. Mota, CNPAF, EMBRAPA
	Ms. María de Lourdes Soares, CNPAF, EMBRAPA
Administrative Advisor:	Dr. Almiro Blumenschein, Chief, CNPAF, EMBRAPA

C. USAID Project Officer: Mr. Howard Lusk, US Embassy, Brasilia, Brazil

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives: The goal is to develop improved techniques, research strategies and methodology for use by bean breeders worldwide in the development of multiple disease resistance

in Phaseolus vulgaris L. Particular emphasis will be given to six diseases which are especially important to Brazil and all of Latin America: anthracnose (Colletotrichum lindemuthianum), angular leaf spot (Isariopsis griseola), common blight (Xanthomonas campestris pv. phaseoli), rust (Uromyces appendiculatus) bean common mosaic virus and bean golden mosaic virus. Efficient, practical techniques for use in greenhouse, screenhouse and field will be developed. Supportive research to provide background data on expected stability of resistance will also be undertaken. This will involve studies concerning pathogen variability and an emphasis on screening methods which detect general or rate-reducing resistance as well as specific resistance.

B. FY 84 Objectives

1. Evaluate dry "natural" inoculum of Xanthomonas phaseoli, Isarioposis griseola and Colletotrichum lindemuthianum for inoculation of beans.

2. Develop a multiple inoculation schedule for five bean pathogens.

3. Continue to study the variability of bean pathogens in Brazil.

4. Continue to evaluate disease testing sites in Brazil.

5. Continue to test collections of bean strains for resistance to bean pathogens.

III. CHANGE IN FY 84 OBJECTIVES

After an extensive process of project review, the following objectives were pursued:

A. Develop techniques for multiple disease testing of germplasm under growth chamber, greenhouse and field conditions.

B. Develop methods for field screening of germplasm with selected pathogens.

C. Determine the variability of selected pathogens.

D. Determine environmental influences on the development of selected diseases.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Administrative: Delays occurred in purchasing equipment; however, procedures have been established which should make equipment importation easier. Also, procedures are now available to ship supplies purchased in the US directly to CNPAF. Scientists have spent many hours on the review of this project.

B. Physical-logistical: Some difficulties were experienced in Brazil with the culture incubators. Also, greenhouses in Brazil are not adequately cooled so there is a delay in experimentation.

V. PROGRESS TOWARD OBJECTIVES

A. Multiple Disease Evaluation: The investigation of new techniques for multiple disease testing of germplasm has progressed under growth chamber, greenhouse and field conditions. Promising results were obtained using sequential inoculations in the field and greenhouse (Brazil) and simultaneous inoculations in the greenhouse and in growth chambers (US). A protocol for screening for disease resistance with multiple pathogens will be available in the near future. In addition, the use of detached trifoliolate leaves in glass dishes in growth chambers offers a way to carefully investigate, evaluate and verify various phenomena observed when multiple inoculations are done in the greenhouse or field (US).

B. Field Evaluation for Disease Reaction: A new technique using dry rather than liquid inoculum to inoculate beans in the field with Colletotrichum lindemuthianum or Isariopsis griseola was confirmed to be reliable and repeatable (US). This technique offers a good alternative to traditionally-used conidial suspensions for field-screening purposes. Methods were developed to prepare and calibrate dry inoculum using simple laboratory procedures.

Bean disease reaction plots have been established in separate locations in Brazil for web blight, bean golden mosaic virus, anthracnose and anthracnose/common blight. Breeding lines planted in these locations were evaluated for their disease reaction and the best lines selected for additional testing.

C. Pathogen Variability: The presence of strains or races of bean common mosaic virus, I. griseola, C. lindemuthianum and Uromyces appendiculatus was evaluated. Several races of each fungal pathogen were detected, but all isolates of bean common mosaic virus were identified as strain number 1 (US type strain).

D. Environmental Influence on Disease Development: A better understanding of the temperature requirements of Isariopsis griseola for development of typical symptoms of angular leaf spot was achieved. Now the symptoms of the disease so apparent in the field (chlorosis and premature defoliation) can be duplicated with greenhouse or growth chamber inoculations.

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use: Dry inoculum techniques for I. griseola and C. lindemuthianum are available for research in the US. These techniques have not yet been adequately evaluated in Brazil.

B. Available for Use Within One to Two Years: A protocol for evaluation of bean germplasm to four pathogens (Xanthomonas campestris pv. phaseoli, Uromyces appendiculatus, I. griseola and C. lindemuthianum) will be available soon. Field testing is underway in Brazil.

VII. TRAINING OUTPUTS

A. Dr. Debra Inglis is a post-doctoral fellow at the University of Wisconsin, Madison. She is studying with Dr. D. J. Hagedorn.

B. One Brazilian laboratory technician received short-term training (three months) in Brazil on laboratory and field disease evaluations.

VIII. BASELINE DATA

A. Techniques for multiple pathogen inoculation of beans are not available.

B. A few Brazilian bean cultivars have race-specific resistance to no more than two pathogens. The extent of general resistance in bean cultivars is very limited.

C. Bean germplasm with resistance to bean golden mosaic is not available.

IX. WOMEN IN DEVELOPMENT

A. United States: Dr. Debra A. Inglis has major responsibility for research at the University of Wisconsin. She has hired a woman hourly laboratory helper.

B. Brazil: Dr. María J. Zimmermann has joined the project as a plant breeder. She has responsibility for the national bean program in Brazil. Two women laboratory helpers have assisted with the technical aspects of this project.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States

1. Personnel

Dr. Douglas P. Maxwell, chairman and professor, 15 percent
Dr. Donald Hagedorn, professor, 40 percent
Mr. Robert Rand, specialist, 40 percent
Secretaries, 20 percent
Greenhouse supervisor, 2 percent
Budget and fiscal specialists, 2 percent
Superintendent at experimental farms, 2 percent
Approximate value: $38,000

2. Student training: None.

3. Facilities

Research laboratories, 1-1/3
Offices, 1-1/2
Greenhouse space, 90m^2
Experimental fields: Hancock Experiment Station, 0.6 ha; Arlington Experiment Station, 0.4 ha
Vehicle, 60 percent

4. Materials and supplies: $200

5. Travel/transportation: None.

6. Indirect costs: $12,125

B. Brazil

1. Personnel

Dr. J. C. de Faria, CNPAF, 90 percent
Mr. A. Sartorato, scientist, 15 percent
Mr. C. A. Rava, scientist, 15 percent
Dr. A. Blumenschein, Chief, 2 percent
Secretary, 15 percent
Phototrapher, 2 percent

2. Student training: One (for three months)

3. Facilities

Research laboratory, two
Office, 1-1/2
Greenhouse, 200m^2
Experimental fields: Fazenda Capivara (GO), 4.0 ha; Rio Verde (GO), 1.0 ha; Uberaba (MG), 0.7 ha; Irati (PR), 2.0 ha; Londrina (PR), 0.7 ha; Pelotas (RS), 0.06 ha; Poco Verde (SE), 0.06 ha; Santana do Ipanema (AL), 0.06 ha; Lagoa Seca (PB), 0.06 ha; Venda Nova (ES), 0.01 ha
Vehicle, 5 percent

4. Materials and supplies: As necessary.

5. Travel and transportation: Travel provided to all experimental plots.

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages

1. United States: Dr. R. Durbin, Department of Plant Pathology, UW, Madison evaluated toxin production by Isariopsis griseola.

2. Brazil

a. Dr. Fernando Assis Paiva, Uberaba, MG, helped with pathogen identification.

b. Dr. Guilhermo Galvez, Costa Rica, supplied seed for evaluation.

c. Information exchange continued with Dr. Dermot P. Coyne, University of Nebraska (UNE), Lincoln (Dominican Republic (DR)/UNE Bean/Cowpea CRSP project).

d. Contact was maintained with Dr. George F. Freytag, Mayagüez, University of Puerto Rico (UPR) (DR/UPR Bean/Cowpea CRSP project).

e. Dr. R. Stavley, USDA, Beltsville, Maryland supplied seeds for race determinant for bean rust and information on rust typing.

f. Dr. J. C. Dianese, University of Brasilia, Brasilia worked on strain determination of bean pathogen.

B. Ongoing Linkages

1. United States

a. Relationships were maintained with Drs. J. López-Rosa, G. Freytag and J. Beaver, Mayagüez, UPR (DR/UPR Bean/Cowpea CRSP project).

b. Information exchange continued with Drs. J. Steadman and D. Coyne, UNE (DR/UNE Bean/Cowpea CRSP project).

c. Contact was maintained with Dr. M. J. Silbernagel, Washington State University (WSU), Prosser, WA (Tanzania/WSU Bean/Cowpea CRSP project).

d. Drs. Aart van Schoonhoven, S. Temple, and M. A. Pastor-Corrales, CIAT, Cali, Colombia supplied seed.

e. Drs. S. K. Mohan and T. Mohan, Fundacão Instituto Agronômico do Paraná, Londrina, Paraná, Brazil assisted with race determination and field evaluation.

2. Brazil: Relationships were maintained with Drs. S. Temple and M. A. Pastor-Corrales, CIAT, Cali, Colombia.

(II. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategies

1. United States

a. Objective: To further develop and utilize techniques for multiple disease testing of germplasm under growth chamber and greenhouse conditions.

Strategy: Seedlings grown in pots will be simultaneously and sequentially inoculated with U. appendiculatus, X. campestris pv. phaseoli, I. griseola and C. lindemuthianum.

Experimental factors considered will be placement of inoculum, timing of inoculations, concentration of inoculum and environmental conditions. It is anticipated that this information will lead to a scheme which can be used for field inoculations.

b. Objective: To further investigate methods for preparing and storing dry inoculum of I. griseola and C. lindemuthianum produced in the laboratory and used in field inoculations.

Strategy: Inoculum will be grown in glass jars on natural media (e.g. sorghum seed, rice seed, bean pods). Once the inoculum is dried and ground, the number of surviving propagules under different storage conditions will be assessed by dilution plating techniques. The relationship between viable inoculum and disease development will also be determined.

c. Objective: To study the possible protective and/or synergistic interactions among pathogens and races of a pathogen which are observed when multiple inoculations are done in the growth chamber, greenhouse or field.

Strategy: Whole plants as well as detached trifoliolate leaves in glass dishes will be inoculated and maintained in growth chambers to further characterize the nature of the interactions between pathogens. The cause of these interactions will be pursued.

2. Brazil

a. Objective: To complete the evaluation of the multiple disease inoculation protocol for use under field conditions.

Strategy: Beans will be simultaneously and sequentially inoculated with four pathogens (X. campestris, U. appendiculatus, phaseoli, I. griseola and C. lindemuthianum) under field conditions. The experimental factors will be: cultivars, timing of inoculation, sequence of pathogens used in inoculation and the use of maize border rows around the plots. It is anticipated that these experiments will provide information which can be used to formulate a protocol for multiple pathogen inoculation of a large field. An experiment will be performed to compare results of a small disease nursery with those from a large field plot.

b. Objective: To evaluate the disease reactions for X. campestris pv. phaseoli obtained on primary leaves prick-inoculated in the disease nursery with the adult plant reaction under field conditions.

Strategy: Primary leaves of young plants will be prick-inoculated with the bacterium under disease nursery conditions. On the same day, plots planted to the same bean cultivars will be subjected to inoculation by three different techniques: (1) sand-blast plants and then spray bacterial cell suspension onto them; (2) mix carborundum with bacterial suspension and spray plants; (3) spray plants with a bacterial suspension at high pressure.

c. Objective: To study the role of rate-reducing resistance to control bean diseases.

Strategy: After identification of specific races of the pathogens, selected highly aggressive races will be used to assess parameters known to correlate with rate-reducing resistance, such as infectious efficiency (frequency), latent periods, colony and lesion size and spore production. Since this type of resistance generally shows a more continuous quantitative type of variation among host cultivars, quantification of disease rather than the use of the infection type only will be attempted.

d. Objective: To study the genetic variability of selected bean pathogens.

Strategy: Collections of new isolates of bean pathogens are continually made during field visits to different regions. The plant material is brought to the lab, the fungus/-bacteria isolated and inoculated onto a set of differential cultivars for race determination. An isolate is also maintained for future studies. These studies allow an evaluation of a shift in virulence genes over time.

e. Objective: To develop procedures for evaluation of resistance to bean golden mosaic virus.

Strategy: Disease nursery and management plots will be established in three locations. The disease nursery plots will contain over 400 accessions from CNPAF, CIAT and other research programs. The smaller management plots will be planted with six cultivars and the level of white flies controlled. These plots should provide information on the connection of insect vector pressure to disease severity.

f. Objective: To evaluate the inoculation procedures used for detection of multiple disease resistance plants in breeding lines and development of multiple disease resistant germplasm.

Strategy: Breeding lines from crosses between parents with resistance to different diseases will be inoculated using the multiple inoculation techniques previously developed. These crosses are being made by scientists at CNPAF and CIAT.

Germplasm resistant to bean golden mosaic virus is being developed. Interspecific crosses between Phaseolus spp. are being made by CNPAF and CIAT. Material generated from these crosses will be evaluated at the level of F_3-F_4 families.

A complete strategy for selection of multiple disease resistant germplasm will be developed.

g. Objective: To study the observed interaction between rusts and anthracnose.

Strategy: Plants resistant and susceptible to anthracnose will be inoculated with rust and at different intervals with C. lindemuthianum. The possible cause of this interaction and the possibility of avoiding it will be pursued.

B. Training Objectives and Strategies

1. United States: A research associate from the US will join the project at CNPAF, Brazil in November 1984.

2. Brazil: A workshop on bean breeding for multiple disease resistance will be presented at CNPAF, May 1985. It will consist of six to ten days of lectures, discussions, demonstrations and field trips for ten to fifteen scientists from Brazil. Instructors will include mainly CRSP project personnel. Brazil scientists will attend national meetings and visit major research programs on bean diseases.

C. Anticipated Personnel/Locational Changes

1. Dr. M. J. Havey, research associate at UW, Madison, will join the research group at CNPAF in November 1984.

2. Dr. María J. Zimmermann, bean breeder at CNPAF, will become more involved with this project.

3. Dr. D. A. Inglis, research associate, will terminate her appointment in April 1985 at UW-Madison.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Faria, J. C. 1984. Identification of Common Bean Germplasm with Low Bean Common Mosaic Virus Seed Transmissibility. 1984 Annual Meeting, American Phytopathological Society, Guelph, Ontario, Canada, August 12-16, 1984 (Abstracted in Phytopathology 74:818).

Inglis, D. A. and D. J. Hagedorn. 1984. Temperature Requirements by Isariopsis griseola (IG) for Infection and Disease Development on Red Kidney Beans. 1984 Annual Meeting, American Phytopathological Society, Guelph, Ontario, Canada, August 12-16, 1984 (Abstracted in Phytopathology 74:856).

Inglis, D. A., Hagedorn, D. J. and R. E. Rand. 1984. Using Dry Inoculum in the Field for Testing Beans for Resistance to Angular Leaf Spot. 1984 Annual Meeting, American Phytopathological Society, Guelph, Ontario, Canada, August 12-16, 1984 (Abstracted in Phytopathology 74:884).

_____. 1983. A New Technique for Testing Beans for Resistance to Anthracnose and Angular Leaf Spot. Proceedings of the 1983 Biennial Meeting of the Bean Improvement Cooperative, Minneapolis, MN, November 7-10, 1983 (Abstract).

CAMEROON • UNIVERSITY OF GEORGIA

Pest Management Strategies for Optimizing Cowpea Yields in Cameroon

I. PROJECT ROSTER

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

Principal Investigator:	Dr. Richard B. Chalfant, Department of Entomology, UGA Coastal Plain Experiment Station (CPES)
Co-Principal Investigators:	Dr. J. A. A. Renwick, Boyce Thompson Institute (BTI)
	Dr. Pat Hughes, BTI
Research Associate:	Dr. Frank Messina, BTI
Technician:	Ms. Joyce Barmore, PTI
Administrators:	Dr. W. C. McCormick, Director, UGA CPES
	Dr. Max Bass, Head, Department of Entomology, UGA
Contracts and Grants Officer:	Mr. Ted Proffer, College of Agriculture Business Office, UGA
Institutional Representative:	Dr. Charles Laughlin,, Associate Director of the Agricultural Experiment Stations, UGA

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

Principal Investigator:	Mr. Zachee Boli, IRA Maroua Station Director
Research Associate:	Dr. Moffi E. Ta'Ama, IRA
Research Counterparts:	Mr. Endondo Chevalier, IRA
	Mr. Georges Ntoukam, IRA
Technicians:	Mr. Amboui Bellow, IRA
	Mr. Vatsayi Hayata, IRA
	Ms. Dominique Amadou, IRA
	Mr. Tchiegue, IRA
	Ms. Mele Kairama, IRA
	Ms. Mariel Nguizaye, IRA
	Ms. Rachel Kobu, IRA
Administrator:	Dr. J. P. Eckebil, Director, IRA
Secretaries:	Ms. Gousman, IRA
	Ms. Fadimatou, IRA

C. USAID Project Officer: Dr. Abdel Moustafa, USAID/Yaounde

II. PROJECT OBJECTIVES

A. Overall (Five-Year) Objectives

1. United States

a. Identify behavior modifying chemicals' potential for management of major cowpea insect pests.

b. Characterize the chemical and ecological nature of plant resistance.

2. Cameroon

a. Identify key cowpea insect pests and their biology within the principal cowpea-producing areas of northern Cameroon.

b. Evaluate cowpea cultivars for resistance to major insect pests and characterize the mechanisms for resistance to facilitate breeding for resistance.

c. Identify factors within cropping systems which affect insect-plant relationships.

d. Develop and evaluate pest management methods suitable for small farmers in northern Cameroon.

e. Train Cameroonian students and technicians for entomological research.

B. FY 84 Objectives: The objectives listed above are being pursued. Increased research on storage insects, aphid resistance and mixed cropping is planned.

III. CHANGES IN FY 84 OBJECTIVES: No changes were necessary.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Telecommunication is difficult within Cameroon and between the US and Cameroon.

B. The attempted coup d'etat in 1984 has placed strains on travel.

C. Religious and social customs make integration of WID more difficult.

D. There are insufficient funds to expand research to new locations.

E. Cost sharing between IRA and the CRSP is not well defined.

F. Confusion has occurred in lines of communication and responsibilities among the various administrative units associated with the project.

G. Technicians are insufficiently trained.

H. There are insufficient vehicles, and transport of supplies is difficult.

I. Permits to purchase equipment are difficult to obtain.

J. There is a need for a secretary/bookkeeper.

I. Computing facilities are needed.

V. PROGRESS TOWARD PROJECT OBJECTIVES

A. Cameroon: Results reported here represent an expansion from eight experiments in two locations in 1982 to twenty-three experiments in seven localities in 1983. Rainfall was adequate (533 mm) at the main station in Maroua (Guering) but less than at the other stations (700-800 mm). Results are as follows:

1. A short-season, local cowpea cultivar, VYA, was identified which yields as well as the improved cultivar, TVX3236-0IG, when both are planted at proper densities (25,000, 100,000 plants/ha, respectively)

2. Yield loss studies indicate best yields were obtained with improved cultivars TVX3236-0IG, TVX1948, VITA 7 and local cultivars VYA and MOGODA. Knowledge of optimum density would improve results.

3. FG Maruca resistant cowpeas and local cultivars were evaluated in observational plots. Five of these had acceptable yield, grain color and foliage production for forage.

4. Date of planting studies indicated that mid-July was more acceptable than mid-June or mid-August for grain production. Seed quality suffers from June planting while peas planted in August may suffer from drought although seed quality is good.

   The cultivar IT82E60-0IG (60-day maturity) was very susceptible to diseases and insects, particularly when planted in June or July.

5. Five international varietal trials comprising sixty-four cultivars from IITA and SAFGRAD were made. Their yields were generally superior and double those of the local cultivars affected by early drought.

   In trial 1, IT82E67, IT82E56, IT82E60 and IT82E77 were most acceptable. In trials 2 and 3, best yields were obtained with TVX3236, TVX1948-012 and TVX4656, IT81D988, IT81D985 and IT81D996. In the lab, IT81D985 showed resistance to bruchids.

   Of the early-maturing SAFGRAD varieties, SIVATA 2, TVX1999-0IF, White Wonder and IAR68 produced best, but the grain quality was not acceptable to northern Cameroon.

6. Among various methods for expressing and counting thrips in cowpea flowers, the acetic acid method was more effective than alcohol or visual counts and sticky traps.

7. Economic threshold studies of thrips were confounded by simultaneous floral infestations by Maruca.

8. At Guering (Maroua) a test comparing the conventional knapsack spray method with the Electrodyn (electrostatic, waterless

sprayer) indicated that the latter was 15 percent more effective against thrips; however, this difference was not reflected in yield.

9. A test with different insecticides formulated for the Electrodyn sprayer showed that Cypermethrin plus Dimethoate formulation at 15 + 20 g/ha was more effective against thrips and aphids than a Cypermethrin + Chlorpyrifos mixture or Cypermethrin alone.

10. Electrodyn sprays using doses of 30 + 60 g/ha of Cypermethrin + Dimethoate on two cowpea cultivars produced better results at Sanguere where insect pressure was greater. Control of thrips at Maruca was significantly better with the Electrodyn than with the water-base Solo knapsack sprayer.

11. At Sanguere, under heavy insect pressure, one, two and three insecticidal applications increased yields two, fifteen and twenty-two times.

12. Different insecticides were evaluated for control of the various insect pests of cowpeas. Although significant differences in efficacy occurred, these differences were not reflected in the yields.

13. Studies of sorghum-cowpea intercropping showed that the cultivars TVX3236-0IG (cowpeas) and S-35 (sorghum) were better adapted to mixed cropping than cowpea cultivars VITA5 or VYA or sorghum cultivar Mogoda.

14. Cotton and peanut oils in doses of ten ml/kg seed gave satisfactory control of the cowpea weevil on stored cowpeas if the initial infestation was light; however, the oils produced a discoloration of the seed and 12 percent less germination.

15. Of the chemicals evaluated to control the cowpea weevil, only phostoxin (aluminum phosphide) was satisfactory. Actelic (pirimophos methyl), deltamethrin and Nexion (bromophos) were less effective.

16. Of ten cultivars from IITA tested for resistance to the cowpea weevil in the laboratory, IT81D985 sustained less damage than the local check variety.

B. United States--Boyce Thompson Institute

1. The life cycle of the active form of the cowpea weevil was analyzed to determine how it could be monitored and manipulated.

2. Differences among cowpea weevil strains from IITA (Nigeria), Cameroon and Florida have been determined.

3. The production of active weevils was found to be controlled by genetic and environmental factors.

4. Resistance to cowpea weevils in improved IITA cowpea lines was traced to increased cowpea weevil developmental time.

5. IITA cowpea lines identified as cowpea aphid resistant did not hold up in US experiments.

6. Four PI lines from Experiment, GA, showed moderate resistance to the cowpea aphid.

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use: The following results have been obtained:

1. Safe pesticides for control of major pests.

2. Desirable planting dates.

3. An improved cowpea cultivar adapted to northern Cameroon which has increased yield and is thrips resistant over local landraces.

4. Information on the biology of the cowpea weevil and prediction of damage.

B. Available for Use Within One to Two Years: These outcomes are anticipated:

1. Methods for control of storage insect pests.

2. Improved varieties for cowpea/sorghum mixed cropping.

3. Information on use of pheromones for management of the cowpea weevil.

4. Information on effects of environment on stability of aphid resistance in cowpeas.

5. The most effective aphid and weevil resistant lines for Cameroon will be identified.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
None						
Cameroon Citizens:						
Ntoukam	M	UGA	Entomology	M.S.		Total
Others:						
None						

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
None					
Cameroon Citizens:					
Ntoukam	M	IRA	MSTAT Wrkshp.	MSU	One week
Tchougnia	F	IRA	App. Ent.	Maroua	Two mos.
Amadou	M	IRA	App. Ent.	Maroua	Six mos.
Tchiegue	M	IRA	App. Ent.	Maroua	Six mos.
Nguizaye	F	IRA	App. Ent.	Maroua	Six mos.
Kobu	F	IRA	App. Ent.	Maroua	Six mos.
Kairama	F	IRA	App. Ent.	Maroua	Six mos.
Others:					
None					

Mr. Georges Ntoukam of the Institut de la Recherche Agronomique entered the University of Georgia in the M.S. program under Dr. R. B. Chalfant. Five Cameroonian technicians have been trained in applied entomology at the project site in Maroua. Mr. Ntoukam also received MSTAT microcomputer training for one week at Michigan State University.

VIII. BASELINE DATA

A baseline data survey was conducted in northern Cameroon. The sample size was 240 families divided equally into 48 villages, 12 subdepartments and 6 departments. The results (partial and not analyzed) are as follows:

A. Sex: 100 percent male.

B. Crops grown: Cowpeas 75 percent, peanuts 62 percent, millet 28 percent, cotton 49 percent, corn 25 percent.

C. Grown in association with cowpeas: Sorghum, millet.

D. Sixty-seven percent practiced mixed cropping.

E. Number of crops grown in association: Average of one (range 0-3).

F. Two or three seeds are placed per hill.

G. Land preparation: Flat 84 percent, ridges 10 percent, mounds 6 percent.

H. Thinning of cowpeas: 23 percent do, 77 percent do not.

I. Peas are weeded an average of two times.

J. Factors that affect yield are insects 47 percent, rain 41 percent, weeds 11 percent.

K. Grain color preference: White 72 percent, red 14 percent, brown 12 percent, multicolor 2 percent.

IX. WOMEN IN DEVELOPMENT

A. United States: One woman has been trained as a technician at BTI.

B. Cameroon: Three women are being trained as technicians in entomology at Maroua.

C. Impact: Women do most of the weeding, harvesting and some of the selling in northern Cameroon. Improved cultivar 3236 is easier to harvest thus reducing time and labor. Effective herbicides delineated by the project reduce time-consuming hand weeding. Increased yield makes more food available for families under care of women.

A Women in Agriculture Resource Guide was prepared for this project. This provides valuable information on women's roles in agricultural production in northern Cameroon.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States

1. Personnel

a. University of Georgia

Dr. Richard B. Chalfant	30 percent	$13,500
Two technicians	53 percent	14,491
Three secretaries	20 percent	22,266

b. Boyce Thompson Institute

Dr. J.A.A. Renwick	25 percent	$23,500
Dr. Pat Hughes	15 percent	combined

2. Student training: One in Masters program, $20,000 value.

3. Facilities: University of Georgia and Boyce Thompson Institute: 4 offices, 4 laboratories, 2 greenhouse units, 6 acres plot land, 1.5 vehicles, $30,000.

4. Material and supplies: Approximately 20 percent of the total value of laboratory, building and research maintenance is contributed to the project.

5. Travel/transportation: Approximately 20 percent of vehicle time and maintenance of three trucks are contributed.

6. Indirect costs: $24,590.

B. Cameroon

1. Personnel

a. Mr. Endondo Chevalier and Mr. Georges Ntoukam. agricultural engineers, 100 percent of time, $13,000

b. Two technicians, 100 percent of time, $2,500

2. Student training: None

3. Facilities: Offices and laboratories, 1000 square feet, plot land 30 ha, 1.5 vehicles.

4. Materials and supplies: One furnished house, running expenses, $25,000 per year.

5. Travel and transportation: $2,000

6. Indirect costs: $10,000.

(I. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages

1. Delegation of Protestant Missionaries: Demonstration trials were established in Gamboura.

2. Société de Developpement du Coton (SODECOTON): Involvement was increased due to significant value of cowpeas made evident by this CRSP project. SODECOTON has a mandate for food crop production and has established extension infrastructure.

3. Centre de Recherche Forestier: Intercropping cowpeas with reforestation is being investigated.

B. On-Going Linkages

1. United States

a. USDA/Agricultural Research Station (ARS) Insect Biology Laboratory, Tifton, GA: Plot land and technical advice is supplied.

b. USDA/ARS Stored Insect Products Laboratory, Savannah, GA: Technical advice and cooperation are lent.

c. USDA/ARS Vegetable Breeding Lab, Charleston, SC: Technical advice and cowpea cultivars are given.

d. USDA/ARS Insect Attractants Lab, Gainesville, FL: Technical advice and insect-trapping equipment are given.

e. USDA Plant Introduction Station, Experiment, GA: Cowpea plant introductions are supplied for field evaluation.

f. Auburn University, Department of Horticulture, Auburn, AL: Cowpea seeds and technical advice are given.

2. Cameroon

a. Semiarid Food Grain Research and Development Project (SAFGRAD), Cameroon: The project works cooperatively with the SAFGRAD agronomist in pre-extension trials.

b. National Cereals Research and Extension Project (NCRE): Cooperative experiments with the sorghum breeder are conducted.

c. IITA, Ibadan Nigeria: Statistical analysis, computer time, cowpea seeds, insecticides and equipment were supplied.

d. Seed Multiplication Program, Cameroon: Cooperation takes place on multiplication of cowpea germplasm, and plot land is donated.

e. Société d'Expansion et de Modernisation de la Riziculture de Yagoua (SEMRY): Cooperative experiments are undertaken, and land for seed increase is supplied.

f. Agrilagdo, irrigated rice, Garoua, Cameroon: Extension trials and land for seed increase are shared.

g. Catholic Order of Sacred Heart, Mokolo, Cameroon: Cooperative research is being undertaken along with pre-extension trials.

h. Groupment d'Etudes et de Recherché pour le Developpement de l'Agronomie Tropicala (GERDAT): Cooperative research with the entomologist is undertaken.

XII. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy

1. United States

a. Evaluate cowpea germplasm for resistance to major insect pests.

b. Study biology of the cowpea weevil in relation to control.

c. Evaluate methods for controlling the cowpea weevil on stored cowpeas.

2. Cameroon

a. Continue germplasm screening for resistance to insect pests with more emphasis on resistance to storage pests and adaptation to mixed cropping.

b. Continue routine evaluation of pesticides with emphasis on low mammalian toxicity.

c. Study chemical, physical and biological methods for control of storage pests.

B. Training Objectives and Strategy

1. United States: The Cameroonian graduate student will continue research at UGA and obtain an M.S. A new Cameroonian student will be identified to replace present one after completion of the degree.

2. Cameroon: The counterpart and technicians will be sent to IITA for short-term training in cowpea entomology. Technicians will be trained in applied entomology at Maroua.

C. Anticipated Personnel/Locational Changes: A secretary/bookkeeper will be obtained at Maroua.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Messina, F. J. 1984. Influence of Cowpea Pod Maturity on Oviposition Choices and Larval Survival of a Bruchid Beetle, Callosobruchus maculatus. Entomologia Experimental et Applicata 35:241-248.

Ta'Ama, Moffi. 1984. Performance of Cowpea Cultivars in Northern Cameroon. Paper presented at the National Cereals Research and Extension Project Conference, IITA, Nigeria, 4-9 March 1984.

_____. 1984. Performance of Cowpea and Sorghum Cultivars for Mixed Cropping. Paper presented at the National Cereals Research and Extension Project Conference, IITA, Nigeria, 4-9 March 1984.

_____. 1984. Cowpea/Sorghum Mixed Cropping. Paper presented at the National Cereals Research and Extension Project Conference, Yaounde, February 1984.

_____. 1983. Yield Loss Studies in Cowpea in Northern Cameroon. Paper presented at the Annual Meeting of the Entomological Society of America, Detroit, MI, November 1983.

DOMINICAN REPUBLIC • UNIVERSITY OF NEBRASKA

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. James R. Steadman, Department of Plant Pathology, UNE
Investigators:	Dr. Anne K. Vidaver, Department of Plant Pathology, UNE
	Dr. D. T. Lindgren, Department of Horticulture, UNE, North Platte
Research Technicians:	Ms. Cheryl Campbell, Department of Horticulture, UNE
	Mr. Larry Einemann, Department of Plant Pathology, UNE
	Mr. William Haskins, Department of Plant Pathology, UNE
	Mr. Douglas Hindman, Department of Plant Pathology, UNE
	Ms. Anne K. Weiss, Department of Horticulture, UNE
	Ms. Beth Cordell, Department of Plant Pathology, UNE
Research Associates:	Ms. C. Ishimaru, Department of Plant Pathology, UNE
	Dr. Meher Shaik, Department of Plant Pathology, UNE
Staff Secretary:	Ms. Terri Short, Department of Horticulture, UNE
Institutional Representative:	Dr. Roger D. Uhlinger, Head, Department of Horticulture, UNE

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

Principal Investigator:*	Ing. Agrón. Freddy Saladin García, Centro Sur de Desarrollo Agropecuario (CESDA), SEA
Plant Pathologists:	Ing. Alfonsina Sánchez, CESDA, SEA
	Lic. Estella Peña, CESDA, SEA
	Ing. Milton Morales, CESDA, SEA
	Ing. Agrón. Bienvenido Montilla, CESDA, SEA

*Ing. F. Saladin replaced Dr. César Paniagua as PI in July 1984.

Agronomists:	Ing. Cristóbal Adames, CESDA, SEA
	Ing. Marino Tejada, CESDA, SEA
Technician/Laborers:	Sr. Orfelino de los Santos, CESDA, SEA
	Sr. Alfredo Perez Vicioso, CESDA, SEA
	Sr. Edgar Amancio, CESDA, SEA
	Sr. Julio de Léon Sánchez, CESDA, SEA
	Sr. Juan Emilio Rosado, CESDA, SEA
	Sr. Francisco A. Valenzuela, CESDA, SEA
	Sr. Leonel Montero Sánchez, CESDA, SEA
	Sr. Sergio Medina, CESDA, SEA
Accountant:	Lic. Francisco Morel-Pimentel, CESDA, SEA

C. USAID Project Officer: Dr. Marion H. Ford, US Embassy, Santo Domingo

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives: Common blight and rust are serious diseases limiting yield of dry beans in the Dominican Republic (DR) and in other countries. This project's aims are to develop methodology, identify pathogen strain variation and resistant germplasm and determine genetic information and strategy that will lead to the incorporation of high levels of more stable resistance to bacterial and rust pathogens. The project is expected to benefit all bean production areas of the world which have these diseases. The research is complementary to the Dominican Republic/University of Puerto Rico Bean/Cowpea CRSP project, the main objective of which is to develop bean varieties resistant to a wide number of pathogens. The Nebraska project complements Puerto Rico's with a more basic genetic and pest management approach.

Resistance to the rust and common blight pathogens has not been stable so there is a critical need to develop new breeding approaches. In addition, because of cost, the use of chemical control is not a realistic disease management strategy for small farms. The best management approach is to develop disease resistant varieties.

B. FY 84 Objectives

1. United States

a. Graduate students: Continue the academic programs of Ing. E. Arnaud-Santana (DR), Ing. W. Ramírez (DR) and Ms. Luann Finke (US) for M.S. degrees and Mr. H. Leyna (Tanzania) and Mr. A. Aggour (Egypt) for Ph.D. degrees.

b. Post-doctorals: Hire two people to work on small rust pustule resistance and on bacterial populations, respectively (epiphytes and seed transmission), in beans.

c. Breeding and genetics: Screen for sources of resistance, study inheritance of reactions and breed for resistance to the above two pathogens in beans.

Dominican Republic

a. Develop clean seed of breeding lines, screen for disease resistance, isolate strains of pathogens, test field performance of lines for yield, seed type, disease resistance and adaptation.

b. Continue the breeding program to develop disease resistant Pompadour and black bean types.

c. Publish the report of baseline data.

III. CHANGE IN FY 84 OBJECTIVES

No change was necessary. Objectives one and two in the proposal were deferred because of lack of trained personnel in the DR. These will be accomplished under the direction of the new project member, Dr. Anne Vidaver (US) in cooperation with recently trained people in the DR.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

The long delay required to obtain AID approval for the purchase of equipment has slowed research progress and interfered with budgets. In addition, delays in shipping and receiving goods in the DR have, with AID delays, postponed needed facility improvements for one-two years.

V. PROGRESS TOWARD OBJECTIVES

A. United States

1. Thesis research

a. Ms. Luann Finke (M.S.): Rust and common blight can be studied simultaneously in the absence of an antagonistic or synergistic interaction. The inheritance of resistance to rust (three strains: two DR, one Nebraska [NE]) and common blight (two strains: one DR, one NE) was studied simultaneously in greenhouse-grown plants of the F_2 and F_3 generations. Pompadour Checa (DR) (resistant to rust, susceptible to common blight) x GN Tara (NE) (susceptible to rust, resistant to common blight). It was hypothesized that two major genes determined the reaction to rust with the dominant gene for resistance exhibiting epistasis. Rust susceptibility was expressed only in the presence of the dominant allele for susceptibility and with homozygous recessive alleles at the other locus. The continuous

distribution of the common blight reaction ratings indicated a quantitative inheritance pattern. No association was detected between the reactions of rust and common blight. Resistance to rust and common blight were readily recombined with Pompadour seed types.

b. Ing. E. Arnaud-Santana (M.S.): The inheritance of resistance to common blight and its relation to flowering and maturity dates were investigated in several crosses. The derived populations were grown in the DR and in Nebraska, but successful inoculation was not achieved in the DR. An experiment was conducted to study the effect of photoperiod and temperature on the reaction of beans to common blight using growth chambers. The effect of photoperiod on the reaction was also investigated in the field. Plants of some genotypes grown under short photoperiods in the field appeared to be more susceptible to common blight than when grown under long photoperiods, which may explain why Nebraska sources of resistance to common blight are susceptible in the tropics.

c. Ing. W. Ramírez (M.S.): Single pustule isolates of rust obtained from locations in the DR and Nebraska were inoculated on the "new set" of nineteen differential cultivars. The results indicated that some isolates were still mixtures and more isolation is necessary. Repeated screening tests have shown the high resistance of Pompadour Checa to all strains of rust in the DR and Nebraska. A trial to determine the value of plant protection to rust was conducted in Nebraska but was badly injured by herbicide drift and virus infection.

d. Mr. Henry Leyna (Ph.D.): Mr. Leyna died suddenly from unknown causes in November 1983. The thesis showed that both the reaction of pods and leaves to common blight were determined quantitatively and that the genes involved were different. The degree of virulence of the isolates affected the inheritance pattern of the reactions.

e. Mr. A. Aggour (Ph.D.): Crosses were made to study the inheritance of the hypersensitive reaction versus the tolerant reaction to common blight. An experiment was also conducted to compare different inoculation methods on leaves and pods of beans using different strains of the pathogen.

2. Pathology

a. Common blight: Bacteriophage typing (eleven phages) of Xanthomonas campestris pv. phaseoli strains (collected on trips to DR), has shown that forty-eight isolates could be separated into at least nine types. This means that the common blight strains in the DR are not homogenous and, since the distribution of types was random, strains are not restricted to one location. Further tests by bacteriocin

typing are expected to provide more insight into the heterogeneity of the strains. No information is currently available with respect to comparisons with strains from other countries; these experiments are in progress. Thus, plant breeding efforts and tests in the different locations in the DR are representative for exposure to the different strains of the common blight pathogen. Isolations from plants at Arroyo Loro yielded strains that appeared to be Pseudomonas sp. Laboratory toxin studies and greenhouse pathogenicity tests revealed that these isolates were not likely P. syringae, P. s. pv. phaseolicola, nor P. s. pv. tabaci. These isolates were pathogenic on Dark Red Kidney and Pompadour Checa pods but produced almost no symptoms in leaves.

b. Rust: Single pustule cultures of field collections from diverse geographic locations in the DR were inoculated to P. vulgaris differential cultivars as delineated at the Puerto Rico Bean Rust Conference (Bean Improvement Cooperative Report 26:iv-vi). Eight new races were found in collections from 1982 and 1983 in addition to three races previously reported in the US. Pompadour exhibited necrotic lesions or small pustules (500um) to all of the races. Early Galatin, Mexico 309, 51051 and Compuesto Negro Chimaltenango were also moderately or highly resistant when inoculated with DR rust cultures. A number of CIAT lines (international bean rust nursery) showed a resistance reaction in DR field locations. Although common sources of resistance were found, DR rust cultures differed from the US cultures.

3. Breeding and genetics

a. Recombinants for resistance to common blight and rust, as well as Pompadour seed type were found in greenhouse-grown F_2 and F_3 populations derived from the cross Pompadour Checa x GN Tara. The F_4 progeny were again challenged by the two pathogens, and selections were made for resistance to both pathogens. F_5 progeny were grown for increase in a non-disease field nursery in Nebraska. One pod was saved from each plant in each family to test for bean common mosaic virus (BCMV) resistance. Seed of each family was then bulked and will be forwarded to the DR for field testing.

b. The inheritance and association of reaction to rust (two NE strains) and common blight (one NE strain) were studied in the F_2 generations derived from the following crosses: Pinto Colorado 12689 (susceptible to blight, resistant to rust) x NE Pinto EP-1 (resistant to blight, susceptible to rust) and Pinto CO 12699 x GN WM2-81-10 (resistant to rust and common blight). A good fit to a 15:1 ratio of resistant to susceptible plants for rust isolate NP95 was obtained in the first cross while a good fit to a 3:1 ratio of resistant

to susceptible plants was obtained with isolate NP872e. This indicated that the NP95 isolate possessed two different dominant genes for virulence while NP872e had only one dominant gene for virulence. All F_2 plants of the second cross were resistant, indicating that both parents possessed the same genes for resistance. No association between the reaction to both pathogens was observed and Pinto recombinants with resistance to both pathogens were selected and advanced to F_4 for field testing for common blight resistance. Selections possessing favorable maturity and agronomic traits along with high common blight resistance were made for future field trials.

c. Fifteen advanced Nebraska GN and Pinto breeding lines and twenty-seven varieties/lines were evaluated in the field for reaction to a mixture of two virulent NE common blight isolates in a replicated trial at Scottsbluff. A good separation of resistant and susceptible lines was achieved. The same lines were grown in a replicated test in a nearby white mold nursery. NE lines GN-83-11 and GN-83-6 exhibited good levels of resistance to both pathogens and one is being considered for release in Nebraska. An early maturing, upright, small, white breeding line, CSW-5, performed well based on avoidance to white mold, tolerance to common blight, resistance to BCMV, resistance to the North Platte Valley (NE) strains of rust, good yield and seed quality. This line will be released in 1985. IAPAR BAC 6 (Brazil) had the highest resistance to common blight but was not adapted to Nebraska because of late maturity. Forty-eight GN and Pinto NE breeding lines, along with two check varieties, were evaluated in a replicated trial for resistance to white mold and under natural infection of common blight. A number of lines appear promising for further testing as candidates for release based on resistance to white mold, rust, common blight and BCMV.

B. Dominican Republic

1. A new, white-seeded, rust-resistant dry bean variety, Arroyo Loro No. 1, developed by the University of Puerto Rico/Mayagüez Institute of Tropical Agriculture as 2W-33-2 and tested in Bean/Cowpea CRSP trials in the DR for two-and-a-half years, was released.

2. Mean seed yields and yield stability estimates were calculated for seventeen bean lines/varieties grown in eighteen CRSP trials in the DR during 1981-82 and for lines/varieties in ten trials for 1982-83. Regression techniques were used to analyze genotype x environment interactions. Indeterminate genotypes produced greater than average seed yields, had an average or greater than average response to more fertile environments and showed minimum deviations from regression in comparison with the determinate mottled seed class. This indicated that the development of indeterminate mottled beans could contribute to increased and more stable yield in this seed class.

3. The types and numbers of replicated trials, containing from seven to thirty-two entries, that were grown in the DR (September 1983-June 1984) were as follows: nine adaptation, six red pinto production, seven black production, two bacterial blight, two rust, one economic control of rust and one BYAN. Five lines expressed high resistance to rust, while the standard variety Venzuela 44 was very susceptible to rust. BAC-93 (CIAT) and 8241-409 had the highest degree of resistance to common blight under natural infection in the adaptation nursery (Santiago). The lines mentioned above will be useful as resistant germplasm in the breeding program. ICA-Pijao had an extremely high number of root nodules at San Juan de la Maguana, indicating high potential for N_2 fixation. Two black-seeded breeding lines, BAT-240 (CIAT) and MITA 2B-5-1 (University of Puerto Rico [UPR]), performed well based on high yield and rust resistance and look promising for release. Moderate resistance to bean golden mosaic virus was detected in CIAT bean lines DOR-303, BAT-1412 and BAT-1404. Canario 101 exhibited tolerance to BGMV. None of the red-seeded breeding lines had as good a seed color, pattern, shape and size as Pompadour Checa. A number of them, however, combined multiple disease resistance along with good agronomic traits.

4. Breeding program (DR): A number of good determinate and indeterminate selections showing resistance to rust and common blight along with good Pompadour seed type were made in field- and greenhouse-grown F_3, F_4 and F_5 progeny derived from the crosses Pompadour Checa with AL-16 (CIAT) and BAC-6 (Brazil). New crosses were made in the screenhouse between Pompadour Checa x NE Pinto EP-1 (resistant to common blight) and Venzuela 44 x L-226-10 (resistant to common blight).

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use

1. Seed of the new, white-seeded, rust-resistant, dry bean variety Arroyo Loro No. 1 is now available.

2. New germplasm resistance to rust and common blight and information on the inheritance of resistance to the pathogens are being used in the breeding programs in the DR and US.

B. Available for Use Within One to Two Years

1. Prospects are good for the release of two new rust-resistant black-seeded lines and for a possible release of a Pompadour type combining resistance to rust and common blight.

2. Basic information on the heterogeneity of the rust and common blight pathogens, on epiphytic bacterial population characteristics and bacterial seed transmission among genotypes and on the genetic control of the reactions to both pathogens will facilitate the breeding program.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
Finke	F	UNE	Horticulture	M.S.		Partial
Fujimoto	F	UNE	Plant Path.	M.S.		Partial
DR Citizens:						
Santana	M	UNE	Horticulture	M.S.		Total
Ramírez	M	UNE	Horticulture	M.S.		Total
Jimenez	M	UNE	Horticulture	M.S.		Total
Others:						
Aggour	M	UNE	Horticulture	Ph.D.		None

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
None					
DR Citizens:					
Saladin	M	SEA	MSTAT Wkshp.	MSU	One week
Arnaud-Santana	M	UNE	MSTAT Wkshp.	MSU	One week
Oviedo	M	SEA	Bean Breeding Wkshp.	CIAT	Two months
Rodríguez	F	SEA	Same	CIAT	One month
Ramírez	M	SEA	Same	CIAT	Two months
Morales	M	SEA	Bean Disease Resistance	CIAT	Two months
Peña	F	SEA	Same	CIAT	Two months
Others:					
None					

Mr. J. Jimenez is currently enrolled in an intensive English course at UNE, Omaha and will begin his M.S. program in plant breeding at UNE, Lincoln in mid-1985. In addition to the non-degree training listed above, a workshop on bean breeding, anatomy, growth and development, disease and insect problems was conducted in San Cristóbal, DR for DR technicians. CIAT personnel and Dr. J. R. Steadman participated in the workshop, which was organized by Dr. C. Paniagua.

VIII. BASELINE DATA

A baseline data survey was conducted and published in 1983. In general, the most important production problems were due to biotic (deficiency or excess water) and abiotic stresses (insects, diseases). The survey

indicated that 54 percent of farms were one to two tareas in size and only 4 percent of farms were 101 to 300 tareas.

IX. WOMEN IN DEVELOPMENT

A. United States: Dr. Anne Vidaver, Head, Department of Plant Pathology and President-Elect of the American Phytopathological Society, is a co-investigator. Ms. Luann Finke is completing her M.S. degree and worked on a thesis project of direct benefit to the DR. Ms. Debbie Fujimoto, M.S. student in plant pathology, began a project on variation in the common bacterial blight pathogen (.50 FTE). Dr. Carol Ishimaru (post-doctoral) will work with Dr. A. Vidaver on bacterial blight.

B. Dominican Republic: Ing. Alfonsina Sánchez and Lic. Estela Peña (both plant pathologists funded by CRSP-NE) and Mercedes Rodríguez (agronomist) are professionals working at the Arroyo Loro experiment station. Lic. Estela Peña participated in a two-month training program at CIAT, while Ing. Alfonsina Sánchez presented a paper at the Programa Cooperativo Centroaméricano para el Mejoramiento de Cultivos Alimenticios (PCCMCA) meeting in Nicaragua and wrote the report summarizing the baseline data survey. Ms. Graciela Godoy (M.S., Auburn), DR/UPR Bean/Cowpea CRSP project, is a crop protection specialist at CESDA, San Cristóbal.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO THE PROJECT

A. United States

1. Personnel

Dr. D. P. Coyne, plant breeder, 25 percent, $13,310
Dr. J. R. Steadman, fungal pathologist, 25 percent, $9,295
Dr. A. K. Vidaver, investigator, 15 percent, $6,889
Ms. C. Campbell, research technician, 30 percent, $5,244
Mr. L. Einemann, research technician, 20 percent, $2,614
Mr. W. Haskins, research technician, 12 percent, $2,344
Dr. D. T. Lindgren, associate professor, 10 percent, $3,419

2. Student training: Ms. Deborah Fujimoto, $3,872

3. Facilities: Research laboratories, 250 square feet; offices, 100 square feet; greenhouses, 5,148 square feet; experiment fields, North Platte, 1 acre; Scottsbluff, 3 acres; UNE, Lincoln, 1/4 acre.

B. Dominican Republic

1. Personnel

Ing. Milton Morales, breeder, 74 percent, $6,840
Ing. Bienvenido Montillo, agronomist-seed production, 76 percent, $800
Ing. Maritza Rosario, agronomist, 78 percent, $8,400
Ing. Miguel Herrera, agronomist, 100 percent, $4,800
Pablo Maleno Reyes, technical assistant, 73 percent, $2,400

c. Facilities: Research labs 500 square feet; screenhouses 500 square feet; offices 100 square feet; field plot 8 acres.

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages: None.

B. On-Going Linkages

1. United States: Dr. J. R. Stavely, USDA, Beltsville, Maryland; Dr. Howard Schwartz, Department of Plant Pathology, Colorado State University; and Dr. M. Pastor-Corrales, CIAT, are cooperating informally on sources of rust resistance, strains of rust and disease overwintering. (The latter also on common blight). Dr. F. A. Bliss, Department of Plant Pathology, University of Wisconsin, provides information on screening lines for improved N_2 fixation.

2. Dominican Republic: The CRSP program continues to be incorporated in the National Bean Program (institutionalization of project). Drs. S. Temple and G. Galvez, CIAT, actively cooperate in providing lines with multiple disease resistance for testing in planning and in evaluation.

XII. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy

1. United States

a. Pathology

(1) Continue typing of common blight strains with bacteriophages and begin typing strains with bacteriocins.

(2) Initiate bacterial epiphytic and survival experiments (DR and NE).

(3) Continue to evaluate rust pathogen variability, sources of resistance to rust and monitor survival of rust in Nebraska/Colorado.

(4) Investigate small pustule and/or slow rusting reaction with regard to infection mechanisms and stability of resistance.

b. Genetics and breeding

(1) Continue genetic studies on inheritance and the relationship of the hypersensitive and tolerant reactions of beans to the common blight pathogen.

(2) Initiate a study to determine if different inoculation methods result in different inheritance patterns to the common blight pathogen.

(3) Continue studies on the inheritance of rust resistance in the Pompadour Checa bean type and the relationship of the Pompadour genes with genes from other sources of resistance.

2. Dominican Republic

a. Release one or two rust-resistant, black-seeded lines.

b. Evaluate the agronomic performance of rust and common blight-resistant Pompadour lines.

c. Plant at different locations and seasons the following bean nurseries (CIAT) to detect useful lines for the DR breeding program and/or useful lines for possible release as varieties; common blight, bean golden mosaic, international bean yield and adaptation, international bean rust, web blight.

d. Expand the crossing phase of the bean program when Ing. E. Arnaud-Santana and Ing. W. Ramírez return to the DR in early 1985.

e. Repeat surveys to study the variation of the rust and bacterial pathogens in the DR.

f. Make a seed collection trip into remote areas to collect Pompadour-type germplasm for use in breeding.

B. Training Objectives and Strategy

1. United States: Complete M.S. programs of Ms. Luann Finke (US), Ing. E. Arnaud-Santana (DR), Ing. W. Ramírez (DR) and Ms. D. Fujimoto. Continue with Ph.D. program of Mr. A. Aggour. Complete intensive English course (six to nine months) of Mr. Juan Jimenez (DR) at UNE, Omaha and then enroll him in graduate school at UNE, Lincoln to pursue an M.S. program. Ms. Mildred Zapata, UPR, will enroll in graduate school at UNE, Lincoln in June 1985 and conduct research in plant pathology. Drs. D. P. Coyne, J. R. Steadman and A. K. Vidaver will continue to take the intermediate course in conversational Spanish.

2. Dominican Republic: Ings. E. Arnaud-Santana and W. Ramírez will return from UNE, Lincoln to San Juan de la Maguana, DR, in early 1985. Further CIAT training of DR technicians and professionals will take place in 1985.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Adams, M. W., D. P. Coyne, J. H. C. Davis, C. A. Francis and P. H. Graham. In press. The Common Bean. In R. L. Summerfield (ed.) Grain Legume Crops. London, UK: Longman.

Beaver, J. S., C. V. Paniagua, D. P. Coyne and G. F. Freytag. 1984. Yield Stability of Dry Bean Genotypes in the Dominican Republic. Submitted to Crop Science. (Available from D. Coyne, Department of Horticulture, University of Nebraska.)

Beaver, J. S., C. V. Paniagua, J. R. Steadman and R. Echavez-Badel. 1984. Reaction of Dry Bean Genotypes to Natural Infection of Foliar Diseases in the Dominican Republic. Submitted to Journal of Agriculture, University of Puerto Rico. (Available from D. Coyne, Department of Horticulture, University of Nebraska.)

Business Farmer (Scottsbluff, NE). 1984. Foreign Bean Research Plays Part in Local Industry. May 1984, p. 4.

Finke, Luann M., D. P. Coyne, J. R. Steadman and A. K. Vidaver. 1984. The Inheritance and Association of Resistance to Bean Rust (Uromyces phaseoli) and Common Blight (Xanthomonas campestris pv. phaseoli) in Dry Beans (Phaseolus vulgaris L.). Paper presented at the 81st Annual Meeting, American Society of Horticultural Scientists held in conjunction with the Canadien Society of Horticultural Science, Vancouver, Canada, August 3-9, 1984 (Abstract in HortScience, 1984, p. 545).

High Plains Journal (NE). 1984. Dry Bean Research Provides Many International Benefits. May 1984, p. 6B.

Journal-Star Agribusiness (Lincoln, NE). 1984. Research Project Could Produce Rust-Resistant Bean Varieties. March 15, 1984, p. 9A.

Leyna, H. K., D. P. Coyne and M. L. Schuster. 1983. The Effect of Inoculation Methods and Inoculum Concentrations on Reactions and Genetics of Resistance to Isolates of Xanthomonas campestris pv. phaseoli (Phaseolus vulgaris). Proceedings of the 1983 Biennial Meeting of the Bean Improvement Cooperative and National Dry Bean Council, Minneapolis, MN, November 7-10, 1983 (Abstract p. 14).

Paniagua, César. 1984. Summary of Results of the CRSP Project in the Dominican Republic, 1981-1983 (translation). Paper presented at the 30th Annual Meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios, Managua, Nicaragua, April 30-May 4, 1984.

Schuster, M. L., D. P. Coyne, T. Behre and H. Leyna. 1983. Sources of Phaseolus Species Resistance and Leaf and Pod Differential Reactions to Common Blight. HortScience 18:901-903.

Steadman, J. R., D. W. Hindman and D. P. Coyne. 1984. Reaction of Rust Pathogen Isolates from the US and Dominican Republic on New Bean Differential Lines. Annual Report of the Bean Improvement Cooperative 27:225 (insert).

DOMINICAN REPUBLIC • UNIVERSITY OF PUERTO RICO

Improvement of Bean Production in the Dominican Republic
Through Breeding for Multiple Disease Resistance

I. PROJECT ROSTER

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

Principal Investigator:*	Dr. James S. Beaver, Department of Agronomy, UPR
Co-Principal Investigator:	Dr. George F. Freytag, Tropical Agriculture Research Station (TARS), US Department of Agriculture-Agricultural Research Station (USDA-ARS), Mayagüez, PR
Investigators:	Ms. Mildred Zapata-Serrano, Department of Crop Protection, UPR
	Mr. Rodrigo Echávez-Badel, Department of Crop Protection, UPR
Research Assistant:	Mr. Luis E. Rivera, Department of Agronomy, UPR
Technicians:	Mr. Hirám Vélez-Martínez, Department of Crop Protection, UPR
	Mr. Samuel Carcamo, Department of Crop Protection, UPR
Controller:	Mr. Jaime Hernandez-Vega, Finance Officer, UPR
Secretaries:	Ms. Hilda J. Carrero, Department of Crop Protection, UPR
	Ms. María Pagan, Department of Crop Protection, UPR
Institutional Representative:	Ing. Miguel González-Román, Sub-Director, Agricultural Experiment Station, UPR

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

Principal Investigator:**	Ing. Agrón. Freddy Saladin García, Centro Sur de Desarrollo Agropecuario (CESDA), SEA
Plant Pathologists:	Ing. Miguel Martínez-Cruz, CESDA, SEA
	Ing. Graciela Godoy, CESDA, SEA
Technicians:	Ing. Agron. Julio C. Nin, CESDA, SEA
	Agrón. Mercedes Rodríguez, CESDA, SEA
	Agrón. Fernando Oviedo, CESDA, SEA
Controller:	Lic. Francisco Morel Pimentel, CESDA, SEA

*Dr. James Beaver replaced Dr. Julio López-Rosa as PI in May 1984.
**Ing. Freddy Saladin replaced Dr. César Paniagua as PI in July 1984.

C. USAID Project Officer: Dr. Marion Ford, US Embassy, Santo Domingo

II. PROJECT OBJECTIVES

A. Produce multiple disease resistant bean germplasm in order to reduce losses due to diseases and increase yield stability of beans in the Dominican Republic (DR).

B. Preserve or improve the agronomic characteristics, yield and quality of bean varieties having the preferred seed type for the DR in order to assure the efficient production of a crop that will meet the acceptance and fulfill the nutritional requirements of the population.

III. CHANGE IN FY 1984 OBJECTIVES: No changes in objectives were made.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Puerto Rico

1. The lack of adequate transportation has limited travel to research substations at Isabela, Limani and Fortuna.

2. A rust race virulent to the B-190 source of genetic resistance appeared at the Isabela substation. Genotypes which have previously shown resistance to rust in Puerto Rico are now susceptible. New, more stable sources of genetic resistance to rust will need to be identified and incorporated into the breeding program.

B. Dominican Republic

1. Inflation and an unfavorable exchange rate for the dollar have resulted in a considerable loss in purchasing power for the project. Much more research could be realized if the project could obtain the more favorable rate of 2.7 Dominican pesos per US dollar.

2. The local plant breeding efforts will be limited until graduate students currently studying at the Universities of Puerto Rico and Nebraska return to the project in the DR.

3. An unreliable source of poor quality water is available for irrigating the Arroyo Loro Experiment Station. A ditch needs to be constructed to divert water from a nearby irrigation canal.

V. PROGRESS TOWARD PROJECT OBJECTIVES

A. Puerto Rico

1. Germplasm from the US and CIAT was evaluated for adaptation and disease resistance. Trials from CIAT included an international bean rust nursery, a bacterial blight nursery, an international

flowering and adaptation nursery, an adaptation nursery containing two hundred fifty promising lines for the Caribbean islands and four preliminary yield trials. Germplasm from the US was evaluated in a national rust nursery and two root rot nurseries.

2. Crossing blocks were planted at the Isabela substation in October and February. A series of crosses and backcrosses were made between genotypes having the Zamorano seed class and different sources of disease resistance.

3. A nursery containing F_3 lines derived from crosses between sources of rust and bacterial blight resistance was evaluated at the Isabela substation for adaptation and rust resistance. The most promising lines were selected and grown in an F_4 nursery in order to evaluate the material for adaptation and bacterial blight resistance.

4. Advanced line yield trials were conducted at the Isabela and Fortuna substations. Genotypes 8241-372 yielded well and had low levels of infection to rust and bacterial blight. These lines have been sent to Honduras for further testing.

5. Single pustule isolates of a rust race virulent to the B-190 source of genetic resistance were obtained at the Isabela substation. These isolates were sent to USDA-ARS plant pathologist, Dr. J. R. Stavley, in order to study their virulence when tested on a differential set of bean genotypes.

6. Field observations were made at the Fortuna and Isabela substations on plots located near sources of inoculum of rust in order to study the nature of survival of rust during the hot and humid summer months. Urediospores were germinated to estimate survival of the pathogen.

7. Selected clones of Phaseolus coccineus with multiple virus resistance, bean golden mosaic virus (BGMV), bean common mosaic virus (BCMV), cowpea mosaic virus (CPMV) and common blight resistance were crossed and tested under greenhouse conditions for virus symptom expression. Resistant and susceptible lines were determined by systemic and latent infection for BCMV. The resistance to BGMV appeared to be lost since no resistant hybrids were observed in the greenhouse. Under field conditions, however, viruses and common blight caused only low levels of damage.

8. Phaseolus coccineus germplasm identified as a good source of multiple virus resistance was used for breeding purposes in order to attempt to transfer the resistance to P. vulgaris lines. P. vulgaris was used as the female and P. coccineus was used as the male parent. Twenty interspecific hybrids were propagated by stem cuttings. Response to inoculation with a necrotic BCMV isolate was studied in the F_1 generation. Approximately 50 percent of the F_1 plants showed necrotic symptoms and the other plants were resistant. Morphological abnormalities on some interspecific hybrids were observed. In

order to determine if the abnormalities were induced by an infectious agent or a cytoplasmic effect, reciprocal grafts were performed. The survival and development of P. coccineus scions on interspecific hybrid stock were normal. In contrast, when P. coccineus was used as stock and the interspecific hybrids as scions, an antagonistic effect was shown by necrosis of the scion and stock branches.

9. Evaluation of populations developed from crosses between sources of recessive gene resistance for BCMV and a group of P. vulgaris advanced lines with unprotected "I" gene resistance to BCMV was conducted under greenhouse conditions. Two crosses gave total protection to the necrotic isolate of the BCMV. This material will be tested under field conditions for adaptation and will be used as a source of resistance to BCMV in the crossing program.

10. A P. coccineus necrotic virus isolate of BCMV was evaluated under controlled conditions at 20°C and under greenhouse conditions. Necrosis developed on host groups 1, 4 and 9. No symptoms were observed on host groups 2, 3, 6, 7, 8 and 10. This necrotic virus isolate seems to be different in reaction to previously described strains of BCMV.

11. Selected lines of Phaseolus acutifolius were inoculated under greenhouse conditions with a virulent strain of Xanthomonas campestris pv. phaseoli. Seed of the most resistant lines was harvested and sent to researchers in the US. This germplasm should be useful in the improvement of P. acutifolius populations and in interspecific crosses as a source of bacterial blight resistance.

12. Forty-seven isolates of Xanthomonas campestris pv. phaseoli were tested for pathogenicity on leaves in the greenhouse and on pods in an environmental chamber. The isolates showed more virulence on leaves than pods. Additional information was obtained for each isolate by the gram test, cell form, reaction on differential media and serological tests.

I. Dominican Republic

1. Macrophomina phaseolina isolates have been obtained from San Cristobal and San Juan de la Maguana. A trial was conducted at San Cristobal which was designed to measure the effectiveness of different inoculation techniques to screen in the field for resistance to Macrophomina phaseolina.

2. The second and third backcrosses were made in order to incorporate the B-190 and L226-10 source of rust resistance into Venezuela 44.

3. A collection was made of weed species which might serve as alternate hosts for the BGMV. Collections were made in all of the major bean producing regions.

4. Close collaboration was maintained with the CIAT bean program. An adaptation nursery containing 250 promising lines for the Caribbean islands was planted at two locations. International nurseries for bacterial blight and rust also were planted. An international bean yield and adaptation nursery for determinate beans was planted at one location. Researchers from CIAT visited the nurseries during the growing season.

5. Seven of the most promising red mottled lines and seven of the most promising black lines were tested in separate replicated yield trials at six locations. Test sites included both experiment stations and farms. The lines were evaluated for yield, agronomic characteristics and disease resistance.

6. Adaptation nurseries were conducted at six locations. These were preliminary trials designed to measure the adaptation of a group of disease resistant lines which might be released as varieties or used as parents in the breeding program.

7. F_3 and F_4 lines have been identified which have a Pompadour seed type, a type II growth habit and rust resistance. Seven F_4 lines have been selected for tolerance to bacterial blight.

VI. RESEARCH OUTPUTS DURING FY 1984

A. Available for Immediate Use

1. Advanced lines have yielded well and have shown good levels of disease resistance under local conditions. These genotypes were sent to the bean breeding program at Colorado State University and to USDA-ARS bean researchers at Michigan State University and Beltsville, Maryland to test for adaptation to US conditions. These genotypes also were tested in Honduras and the DR.

2. Techniques for conducting a field crossing block were refined. The use of drip irrigation to maintain adequate moisture during the growing season was found to increase the percentage of successful crosses. A field crossing block using drip irrigation appears to be a viable low-cost option for bean breeding programs in the tropics.

3. Approximately 400 kg of basic seed of the white-seeded variety Arroyo Loro No. 1 was turned over to the Foundation Seed Department of the Ministry of Agriculture. This seed will be used to produce certified seed which subsequently will be made available to farmers.

4. Dry bean germplasm resistant to two races of the root knot nematode (Meloidogyne incognita) were identified.

5. High yielding black- and white-seeded bean lines have been identified that have a stable performance over a wide range of environmental conditions.

B. Available for Use Within One to Two Years

1. Erect black- and white-seeded lines resistant to BCMV, rust and anthracnose have been tested under local conditions. The most promising lines will be sent to the DR and Honduras for evaluation for adaptation and disease resistance.

2. A group of advanced lines derived from crosses between sources of rust and bacterial blight resistance will be available for evaluation in the DR and Honduras.

3. An inoculation technique for screening for resistance to Macrophomina phaseolina is being developed.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
Vélez-Martínez	M	UPR	Crop Protec.	M.S.		Partial
Dominican Republic Citizens:						
Martínez-Cruz	M	UPR	Crop Protec.	M.S.	2/84	Total
Mateo-Solano	M	UPR	Agronomy	M.S.		Total
Oviedo	M	UPEU*	Agronomy	B.S.		Partial
Deschamps	M	UPR	Crop Protec.	M.S.		Total
Others:						
None						

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
González	M	UPR	MSTAT Wkshp.	MSU	One week
Dávila	F	UPR	Wk w/proj.	UPR	Two mos.
Segarra	M	UPR	Wk w/proj.	UPR	Two mos.
Dominican Republic Citizens:					
Solano	M	UPR	MSTAT Wkshp.	MSU	One week
Nin	M	SEA	Bean res.tech.	UPR & DR	Three wks.
Peña	F	SEA	Plant path.	UPR	Two weeks
Saladin	M	SEA	MSTAT Wkshp.	MSU	One week
Others:					
None					

*Universidad Pedro Enriquez Ureña, Dominican Republic.

The project took an active role in organizing workshops during FY 84. These include partial sponsorship of a bean research workshop held at CESDA research center, San Cristóbal, DR. Other sponsors were CIAT, FAO and the Ministry of Agriculture, DR. The project also partially sponsored the First Regional Caribbean Seminar on Biological Nitrogen Fixation held in Santo Domingo, DR in August. Researchers from the DR, Barbados, Haiti, CIAT, the University of Florida, the University of Wisconsin and the University of Hawaii attended the conference. Other sponsors were FAO, AID-supported biological nitrogen fixation projects at UPR, the UPR and the Ministry of Agriculture, DR.

VIII. BASELINE DATA

Trials continued to be conducted on small farms in several bean-producing regions. An additional year of data will provide a more reliable measure of bean production on small farms in the DR.

IX. WOMEN IN DEVELOPMENT

A. Puerto Rico

1. Ms. Marisol Dávila, an undergraduate student in plant pathology, UPR, worked with the project for two months and received credit toward a summer practical requirement. Ms. Carmen Milagro Alicea, an undergraduate student in agronomy, UPR, is currently working with the project in a similar arrangement.

2. Ms. Mildred Zapata has applied for entrance to the University of Nebraska where she plans to initiate a Ph.D. degree program in plant pathology.

B. Dominican Republic

1. Agrón. Mercedes Rodríguez completed a month of training at CIAT studying conservation of germplasm and seed technology.

2. Ms. Estela C. Peña received training in Puerto Rico and CIAT related to bean pathology with an emphasis toward bacterial diseases.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO THE PROJECT

A survey of resources contributed by the University of Puerto Rico and the Ministry of Agriculture of the Dominican Republic is currently being conducted. Below is a list of some of the resources contributed by both institutions. Estimates of the value of these contributions will be reported in the near future.

A. University of Puerto Rico

1. Personnel: None.

2. Student training: Mr. Híram Vélez-Martínez: Tuition waiver for graduate studies.

3. Facilities

Office space at the Mayagüez campus, UPR	100 square feet
Office space at the Isabela substation	100 square feet
Laboratory space at the Isabela substation	600 square feet
Crossing block at Isabela	800 square feet
Experimental fields at the Isabela substation	3 acres
Experimental fields at the Fortuna substation	2 acres
Experimental fields at the Limani substation	1/2 acre

4. Travel/transportation: Vehicles provided by the UPR agricultural experiment station for travel to the substations.

5. Indirect costs: A major portion of the indirect costs for the project is supported by the University of Puerto Rico. During FY 84, the UPR contributed an estimated $35,329 toward indirect costs.

B. Dominican Republic

1. Personnel: Field laborers (9), Arroyo Loro experiment station, SEA, DR

2. Facilities

Office space at Arroyo Loro experiment station	300 square feet
Office space at CESDA experiment station	400 square feet
Office space at CENDA experiment station	500 square feet
Laboratory space at CESDA experiment station	3300 square feet
Laboratory space at CENDA experiment station	3300 square feet
Greenhouse space at CENDA experiment station	500 square feet
Greenhouse space at CESDA experiment station	800 square feet
Experimental fields at Arroyo Loro experiment station	4.4 acres
Experimental fields at CESDA experiment station	8.0 acres
Experimental fields at CENDA experiment station	6.0 acres

3. Travel/transportation: Vehicles provided by the Ministry of the Agriculture for travel between experiment stations and to on-farm research sites.

4. Indirect costs: All indirect costs are supported by the Ministry of Agriculture. During FY 84, the Ministry of Agriculture of the Dominican Republic contributed substantially toward indirect costs.

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages: The project cooperated with the FAO and AID-supported biological nitrogen fixation (BNF) projects at the Universities of Wisconsin and Puerto Rico by providing partial sponsorship for a BNF workshop held in Santo Domingo during August 1984.

B. On-Going Linkages

1. Cooperation with the USDA-ARS bean research program at TARS has continued. Disease resistant bean germplasm developed from

UPR/TARS collaboration forms an important base for the breeding program for the DR.

2. The project has maintained a high level of collaboration with the University of Nebraska Bean/Cowpea CRSP project in the DR. Trips and DR research plans are coordinated. The result has been a more efficient use of resources by both projects.

3. Bean research in the DR and Puerto Rico continues to benefit from collaboration with the CIAT bean research program. Several CIAT trials of interest to the project were planted in the DR and Puerto Rico. CIAT personnel have traveled to the DR and Puerto Rico to make observations on some of these trials. Several members of the project in the DR took short-term training at CIAT.

4. Cooperative agreements with US universities and participation in Regional Project W-150 have permitted a high level of bean research to be maintained in Puerto Rico.

XII. FY 1985 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy

1. Puerto Rico

   a. Characterization of the BCMV resistance of the Pompadour Checa will be undertaken.

   b. Crosses will be made to incorporate the recessive genes for resistance to BCMV into the Pompadour, black- and white-seeded types.

   c. Backcrosses will be made in order to incorporate some of the multiple virus and common blight resistance found in inter-specific crosses into a more adapted *P. vulgaris* genetic background.

   d. The most promising genotypes of *P. coccineus* from the second and third cycle of recurrent selection will be identified. These individuals will be used to form a population which will be considered for release.

   e. Characterization of the rust race found to be virulent to the B-190 source of resistance will be undertaken by testing it on a set of differential bean varieties.

   f. A group of lines derived from crosses between sources of rust and bacterial blight resistance will be advanced. The most promising advanced lines will be sent to the DR for further testing.

   g. A series of populations derived from crosses and backcrosses between genotypes with the Pompadour seed type and sources of multiple disease resistance and improved agronomic characteristics will be advanced.

h. Screening germplasm from other bean research programs for adaptation and disease resistance will continue. Trials from CIAT will include rust and bacterial blight nurseries. An adaptation nursery of promising lines for the Caribbean also will be conducted.

i. A genetic study will be conducted which will determine the heritability of agronomic traits when crosses are made between large-seeded, determinate beans and small-seeded, indeterminate beans. Genetic correlations between agronomic traits and seed size also will be studied.

j. Pompadour-type beans with sources of resistance or tolerance to BGMV and web blight will be crossed.

2. Dominican Republic

a. Economic losses caused by rust in black and white beans will be studied.

b. The incidence of BCMV in commercial fields will be determined.

c. CIAT bean germplasm will be evaluated for adaptation and disease resistance:

(1) Adaptation nurseries.

(2) International bean rust nurseries.

(3) Golden mosaic nurseries.

(4) Bacterial blight nurseries.

(5) Web blight nurseries.

d. Preliminary yield trials will be carried out for beans with the Pompadour seed type.

e. A survey of bean production by small farmers in the northern regions of the DR will be conducted.

f. Studies of the time of infection and seed infection of common blight are planned.

g. Varietal description and multiplication of basic seed of ICA-Pijao and PC-50, a selection of Pompadour Checa, will be carried out.

h. The yield, adaptation and disease resistance of a group of promising bean germplasm will be evaluated on small farms.

i. The effectiveness of different inoculation techniques in screening for field resistance to ashy stem blight (Macrophomina phaseolina) is to be investigated.

j. The transmission of BGMV by the white flies from weed species to beans will be studied.

B. Training Objectives and Strategy

1. Puerto Rico

a. Ing. Hiram Velez-Martinez will complete the requirements for an M.S. degree in crop protection at the Mayagüez campus, UPR.

b. Ms. Mildred Zapata-Serrano will initiate studies for a Ph.D. degree in plant pathology at the University of Nebraska.

2. Dominican Republic

a. Ing. Manuel Mateo Solano will complete requirements for a M.S. degree in agronomy at the Mayagüez campus, UPR.

b. Mr. Hugo Deschamps will continue an M.S. degree program at the Mayagüez campus, UPR.

c. A DR student to be identified will initiate an M.S. degree program at the Mayagüez campus, UPR.

d. Ing. Julio C. Nin will take a short course in bean technology at CIAT.

C. Anticipated Personnel/Locational Changes

1 Puerto Rico

a. Dr. David Unander will dedicate 10 percent of his time to working with problems related to the bean common mosaic virus.

b. Ms. Mildred Zapata-Serrano plans to leave the project in August 1985 to begin graduate studies at the University of Nebraska.

2. Dominican Republic: Ings. Miguel Martinez and Graciela Godoy will dedicate 20 percent of their time to work on root rot and angular leaf spot problems.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Beaver, J. S. 1984. The Use of Statistics in Bean Research. Paper presented at the Bean Research Workshop, CESDA, San Cristobal, Dominican Republic, October 1984

Beaver, J. S., C. V. Paniagua, D. P. Coyne and G. F. Freytag. 1984. Yield Stability of Dry Bean Genotypes in the Dominican Republic. Submitted to Crop Science. (Available from J. Beaver, Department of Agronomy, University of Puerto Rico.)

Beaver, J. S., C. V. Paniagua, J. R. Steadman and R. Echavez-Badel. 1984. Reaction of Dry Bean Genotypes to Natural Infection of Foliar Diseases in the Dominican Republic. Submitted to Journal of Agriculture, University of Puerto Rico. (Available from J. Beaver, Department of Agronomy, University of Puerto Rico.)

Echavez-Badel, R., G. F. Freytag, J. S. Beaver and J. D. Kelly. 1984. Resistencia de campo al tizon comun del frijol de lineas avanzadas desarrolladas en Puerto Rico. Paper presented at the 30th Annual Meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios, Managua, Nicaragua, April 30-May 4, 1984.

Echavez-Badel, R., J. R. Steadman and J. S. Beaver. 1984. Resultados del vivero cooperativo de la roya del frijol. Paper presented at the 30th Annual Meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios, Managua, Nicaragua, April 30-May 4, 1984.

López-Rosa, Julio. 1984. Five Improved Multiple Disease Resistance Lines Released. Research Highlights (I)2. East Lansing, MI: Michigan State University, Bean/Cowpea CRSP Management Office.

Martinez-Cruz, M. 1984. Estudio del efecto de las cuatro razas del nematodo nodulado (Meloidogyne incognita). M.S. Thesis, College of Agricultural Sciences, Mayagüez Campus, University of Puerto Rico.

Paniagua, C. V. 1984. Results of the Title XII Bean/Cowpea CRSP Project in the Dominican Republic During the Period 1981-1983. Paper presented at the 30th Annual Meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios, Managua, Nicaragua, April 30-May 4, 1984.

Pimentel, Elfrida (ed.). 1984. Fijacion Biologica de Nitrogeno en la Agricultura. Proceedings of the First Regional Caribbean Seminar on Biological Nitrogen Fixation, INDOTEC, Santo Domingo, Dominican Republic, August 6-10, 1984. Santo Domingo, DR: INDOTEC.

Sanchez, A. 1984. Weed Control of Beans in the San Juan de la Maguana Valley of the Dominican Republic. Paper presented at the 30th Annual Meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios, Managua, Nicaragua, April 30-May 4, 1984.

Zapata, M. and G. F. Freytag. 1983. Transmission of Bean Golden Mosaic Virus by Grafting. Proceedings of the 1983 Biennial Meeting of the Bean Improvement Cooperative, Minneapolis, MN, November 7-10, 1983 (Abstract).

_____. 1983. Selected Clones of Phaseolus coccineus with Multiple Virus Resistance. Proceedings of the 1983 Biennial Meeting of the Bean Improvement Cooperative, Minneapolis, MN, November 7-10, 1983 (Abstract).

ECUADOR • CORNELL UNIVERSITY

Agronomic, Sociological and Genetic Aspects of Bean Yield and Adaptation

I. PROJECT ROSTER

A. US Lead Institution: Cornell University (CU)

Principal Investigator:	Dr. Donald H. Wallace, Department of Plant Breeding and Biometry, CU
Co-Principal Investigators:	Dr. Patricia Garrett, Department of Rural Sociology, CU
	Dr. Roger F. Sandsted, Department of Vegetable Crops, CU
Program Coordinator:	Mr. Larry Zuidema, Associate Director, International Agriculture Program, CU
Assistant Program Coordinator:	Ms. Linda Russo, International Agriculture Program, CU
Secretary:	Ms. Reina Walther, International Agriculture Program and Department of Plant Breeding, CU
Accountants:	Ms. G. Saatman, International Agriculture Program, CU
	Ms. Mary Jane Neff, International Agriculture Program, CU
Sociologist:	Ms. Donna Goldstein, Department of Rural Sociology, CU
Nutritionist:	Ms. Carolyn Campbell, Department of International Nutrition, CU
Microcomputers:	Mr. David Golden, Department of Agricultural Economics, CU
Economist:	Mr. Juan Palacios, Department of City and Regional Planning, CU
Contracts and Grants Officer:	Mr. Don K. Enichen, Office of Sponsored Programs, CU
Institutional Representative:	Dr. Edwin Oyer, Director, International Agriculture Program, CU

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

Principal Investigator:	Ing. Cristóbal Villasís, Head, Legume Program, INIAP
Co-Principal Investigator:	Ing. Venus Arévalo, Department of Planning and Agricultural Economics, INIAP
Agricultural Economist:	Econ. Patricio Espinosa, Department of Planning and Agricultural Economics, INIAP
Smallholder Agronomist:	Ing. Jorge Rivadaniera, Head, Program on Research in Production (PIP), INIAP

Field Agronomists:	Ing. Arturo Villafuerte, Legume Program, Santa Catalina, INIAP Ing. Romulo Carrillo, PIP, Portoviejo, INIAP
Field Economist:	Econ. Napoleón Chávez, Department of Planning and Agricultural Economics, Portoviejo, INIAP
Computer Consultant:	Ing. German Diener, Head, Department of Biometry and Statistics, INIAP
US Field Agronomist:	Dr. Wesley Kline, International Agriculture Program, CU
US Field Sociologist:	Dr. Kris Merschrod, International Agriculture Program, CU
Administrators:	Dr. Julio Delgado, Director General, INIAP Ing. Julio Cabrera, Assistant Director General, INIAP Dr. Francisco Muñoz, Head, Santa Catalina Experiment Station, INIAP

C. USAID Project Officers:

Mr. Joseph Goodwin, Agriculture and Rural Development Officer, USAID/Ecuador
Mr. Daryl MacIntyre, Project Advisor in the Agriculture and Rural Development Office, USAID/Ecuador

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives

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

2. 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.

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

4. 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.

B. FY 84 Objectives

1. A central objective was to activate all three components of the project. To do this, Cornell hired a crop scientist and a social scientist for placement in Ecuador.

2. The main objective of socio-economic activities at Cornell was to systematize theoretical and methodological principles derived from research conducted to date. Eight working papers were produced, most in English and Spanish.

3. In the original study zone, Pimampiro, the main objectives were to complete the analysis of survey data, design appropriate experiments, plant trials on smallholders' fields and integrate agronomic and physiological genetic components by planting trials at different altitudes and including altitude in the analysis of results. This has been done.

4. In the new study zone, Manabí, the main objective was to identify regional counterparts and to constitute a team with participation from the region and the central office. This has been accomplished. Germplasm (155 specimens) was collected from participating farmers and is now being multiplied on station.

III. CHANGE IN FY 84 OBJECTIVES

None required.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

As the administrative support network was moving into place during the first part of the fiscal year, Cornell experienced delays, particularly of a financial nature. Nevertheless, a detailed work plan was developed and a corresponding budget elaborated.

The agronomist and the sociologist were selected for field placement. The selection of staff was completed as planned, and the candidates visited Ecuador in March with Drs. Wallace and Garrett. The agronomist, Dr. Wesley Kline, was completing his dissertation at the time of selection, and he finished later than anticipated. He participated in team building meetings at Cornell throughout spring and summer, arriving in Ecuador in August.

Because of difficulties in working relationships, the sociologist originally selected for placement in Ecuador was not offered a long-term position. Another candidate, Dr. Jorge Uquillas, was identified in August. Concurrence from INIAP was received, and Dr. Uquillas was hired effective October 1, 1984. His background is appropriate for emerging project directions.

INIAP has experienced limitations which have impeded more vigorous activity. Two counterparts for the socio-economic activities were on leave for three months each, delaying the completion of secondary data analysis for the new study site. They are now collaborating with the regional counterparts, so preliminary work will be complete prior to field research in April 1985. The agronomist for Pimampiro, Ing. Villafuerte, was hired and conducted research as planned.

The transfer of funds has been a problem, but this has been resolved. In September 1984, there was a change of Director General at INIAP, concomitant with a shift in the political and ideological leadership of

Ecuador. Dr. Garrett's summer trip and the planned project seminar were postponed.

V. PROGRESS TOWARD OBJECTIVES

Substantial progress has been made on the socio-economic, agronomic and physiological-genetic objectives.

Socio-economic research at Cornell emphasized Objective 1. Dr. Garrett and Ms. Goldstein prepared a paper (Working Paper 84.4E) evaluating alternative data collection procedures for pre-intervention farming systems research. This analysis, plus other methodology papers (Working Papers 83.2S; 83.3E; 84.2S; 84.5E), represents efforts to develop an adequate and economical methodology for farming systems activities.

Work also proceeded on the analysis of subzones using agronomic criteria. Unfortunately, what appeared to be a very promising procedure using the Apple II+ and a typographic mapping program to study geographic subzones was not satisfactory. Data input was laborious and output was difficult to interpret. This alternative was abandoned in favor of collaboration with Agronomy and Remote Sensing in the hopes of developing viable procedures for regional analysis.

Agronomic research, as contemplated in Objective 2, also began. INIAP planted its first project-financed experiments in the bean-growing region of Pimampiro, Imbabura. The zone's importance was identified during the first phase of research, summer 1982. Survey research conducted spring 1983 provided more information on farming systems, and Ing. Arévalo's analysis (Working Paper 83.1S) identified priority issues for experiments.

Project research in summer 1982 had determined that farmers in Pimampiro grew red beans primarily for the Colombian market. Preferred varieties were Cargabello, followed by Bola and Magola. Yellow beans (notably Matahambre, literally kills hunger) were produced for domestic consumption. Project research in spring 1983 determined that farmers used rather high seed densities (20-30 cm between plants and 30-40 cm between rows). Agro-chemicals were widely used, and Ing. Arévalo (Working Paper 83.1S) suggests that products were inappropriate. Accordingly, a research goal was to decrease costs of production by reducing use of agro-chemicals. Fertilization, especially use of foliar fertilizer, was a special concern. Research demonstrated that variety, spacing and fertilizer trials were indicated. The Technical Committee of the Santa Catalina experiment station and the head of the Legume Program, Ing. Villasís, designed experiments. INIAP hired an agronomist, Ing. Villafuerte.

Work on Objective 3, concerning potential competition within polycropping systems, can begin in the new study zone, Manabí. Unlike Pimampiro, where most beans are grown in monoculture, in Manabí legumes are polycropped. Germplasm (155 specimens) was collected during spring 1984 in Manabí and was planted in September on station (Chávez, 1984). The multiplication of germplasm is a necessary first step for research in the zone.

Progress was made on Objective 4, the development of appropriate procedures for evaluation research. Dr. Garrett's work on the implications of social stratification (Working Papers 84.1E; 84.6E) and Ms. Goldstein's work on sharecropping and accumulation (Working Paper 84.3E) provide the conceptual basis. These papers suggest that traditional micro-economic accounting techniques are satisfactory for evaluating the impact of technologies on producers and enterprises which are market oriented. Producers and enterprises oriented to subsistence production, however, require different monitoring because they will consume rather than sell increased production. Consequently, the evaluation of nutritional outcomes is critical.

Preliminary research adapting the monitoring of nutritional status to farming systems research has begun. Ms. Campbell, who is finishing a dissertation in International Nutrition, worked for the project during the summer. She has completed literature reviews on the nutritional consequences of agricultural innovations and on nutritional deficiencies in Ecuador and in the study regions. She developed a preliminary research design and provided drafts of several questionnaires. Currently, she is preparing a report summarizing her planning activity. The project has proceeded with the encouragement of International Nutrition at Cornell, USAID/S&T Nutrition and AID/Ecuador.

Finally, consistent with Objective 4, Dr. Kline will focus on problems of seed quality, and Ms. Hall will study storage loss. This was identified as a problem during initial field research in summer 1982, and its importance was emphasized in subsequent field work in spring 1983 (see Arévalo, 1983). A literature search was conducted, and extensive bibliographic materials have been secured or ordered. Necessary instruments have also been purchased. Dr. Kline arrived in Ecuador in August, and Ms. Hall will return in January. Their research is complementary.

During FY 84, research occurred on all project components. Work towards the objectives will continue at current sites.

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use: Efforts are being made to adapt microcomputers to farming systems research. This is reflected in the project's Working Papers, which contain several discussions of farming systems research methodology. There is a general guide to the analysis of agricultural census data by Mr. Palacios and Dr. Garrett (Working Paper 83.2S) and a complementary study of the Province of Imbabura (Working Paper 84.2S). Both papers emphasize why it is necessary to analyze inequality prior to initiating field research. Other papers develop this theme. The paper by Francis et al. (Working Paper 84.5E) discusses several statistical measures of inequality, and the program by Mr. Golden (Working Paper 83.3E) permits calculation of one common measure, a Gini coefficient. Pre-intervention research, using both structured interviews and survey research techniques, is considered in Garrett and Goldstein

(Working Paper 84.4E). These methodology papers were developed specifically for Ecuador, but they have potential international applications.

B. Available for Use Within One to Two Years: Work occurred as planned during FY 84 on the anlysis of agricultural census data using microcomputers (Palacios and Garrett, 1984). This established that the best available statistical program for the Apple was adequate but inelegant. Accordingly, development activities this year require different hardware and software, specifically the IBM PC-XT and SPSS.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
Hall	F	Cornell	Veg. Crops	M.S.		Partial
Ecuador Citizens:						
None						
Others:						
None						

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
None					
Ecuador Citizens:					
Arévalo	F	INIAP	ESL	Ecuador	One year
Three males		INIAP	ESL	Ecuador	One year
Others:					
None					

The project has collaborated with the AID Mission and with INIAP to address the issue of training. INIAP has several staff abroad and, in the past, expressed no desire for additional degree training. During the fiscal year, however, the project financed English language training, primarily to improve the staff's ability to read scientific literature in English. In August, INIAP expressed a desire for additional training, thereby initiating a dialogue.

A master's candidate in vegetable crops was identified to conduct research in Ecuador on seed deterioration. Ms. Hall traveled to Ecuador, identified a counterpart and worked with Ms. Goldstein and Ing. Arévalo in Pimampiro.

VIII. BASELINE DATA

The project makes extensive use of secondary data. Socio-economic information includes agricultural census and published studies about Ecuadoran agriculture. Agronomic data are soils, land use and life zone maps obtained from the planning unit of the Ministry of Agriculture, PRONAREG. Primary data were collected in Pimampiro using both structured interviews and survey research techniques. Project Working Papers (notably INIAP/Cornell Team, 1982; Arévalo, 1983; Palacios and Garrett, 1984; Goldstein, 1984; Francis et al., 1984) document past activities.

Econ. Espinosa and Ing. Arévalo of INIAP's socio-economic unit are collaborating with Ing. Carrillo and Econ. Chávez in Manabí to analyze secondary data for the new site. With active assistance from Dr. Uquillas, a preliminary report will be prepared prior to initiating field research in April 1985. This field work will create the project's baseline data for Manabí. Observation of the germplasm multiplication will also orient field research.

As recommended by the External Review Panel and consistent with the argument in Garrett (Working Paper 84.6E), the project has explored the possibilities of monitoring both the production and the consumption outcomes of agricultural innovations. Work on the design of a nutritional component began this year, and secondary data on this issue have been collected. This seems to be the most appropriate baseline data for households and enterprises oriented to subsistence production.

IX. WOMEN IN DEVELOPMENT

A. United States: The Co-Principal Investigator (Dr. Garrett) is actively involved in teaching, research and writing on women in development matters. Central issues have been discussed in several team building meetings with actual and potential project participants so that both males and females develop sensitivity and expertise regarding women's participation in agriculture.

Very few Ecuadoran agronomists are female. This constrains INIAP's access to female informants, thereby limiting effective farming systems research. The recruitment of North American females (Ms. Goldstein, the sociologist, and Ms. Hall, the agronomist) to collaborate with INIAP fills a need.

B. Ecuador: In the course of field research and analysis with INIAP, Dr. Garrett and Ms. Goldstein have assumed teaching roles concerning women in development issues. Dr. Uquillas is mandated by his job description to continue this educational effort.

A central issue in Pimampiro concerns female farm laborers. The management of small farms is overwhelmingly male. Management, as owner or as share tenant, requires the recruitment and supervision of labor, and it is culturally inappropriate that females supervise males. Women in Pimampiro are hired as wage laborers, at rates which are 25 percent below those of males. Labor displacing

technologies, notably chemical weed control, are potentially deleterious to women. In Pimampiro (Arévalo, 1983), weeding was the most labor-intensive activity, save irrigation. This issue has been discussed with INIAP and will be monitored in the future.

One INIAP counterpart is female. Ing. Venus Arévalo was fully involved in the initial diagnostic research design, conduct and analysis of survey results in Pimampiro. She is the author of Working Paper 83.1S (1983), the document which constituted the basis for the design of trials in Pimampiro. She continues to be involved in work in Pimampiro and in the design of activities for Manabí.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO THE PROJECT

A. United States: Cornell's contribution to the project is primarily in the personnel area:

Dr. Donald Wallace, professor, 20 percent
Dr. Patricia Garrett, assistant professor, 20 percent
Dr. Roger Sandsted, professor, 10 percent
Mr. Larry Zuidema, Associate Director, International Agriculture, 10 percent
Mr. Bruce Rich, field manager, 41 percent
Ms. Pat Long, secretary, 30 percent
Ms. Reina Walther, secretary, 10 percent
Ms. Mary Jane Neff, accountant, 13.5 percent

Contributed fringes	$ 9,078
Contributed indirect	$21,779
Contributed total salary	$37,053

B. Ecuador: INIAP contributes substantially to the project in personnel, field plots, research and office facilities. Aggregate dollar amounts are available.

Contributed time of INIAP personnel:

Dr. Julio Delgado, Director General, 20 percent
Ing. Julio Cabrera, Sub-Director, 20 percent
Ing. Patricio Espinosa, Head, Planning, 50 percent
Ing. Venus Arévalo, agronomist, 100 percent
Ing. Cristobal Villasís, breeder, 50 percent
Dr. Francisco Muñoz, director of station, 20 percent
Ing. Romulo Carrillo, agronomist, 80 percent
Ing. Napoleón Chávez, economist, 80 percent
Ing. German Diener, statistician, 20 percent
Technical personnel, $25,860
Equipment, $ 9,500
Supplies, $ 3,000
Use of existing office and research infrastructure, $28,000

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages

1. United States: The project has been studying the consumption outcomes of agricultural innovations. Contact was initiated with International Nutrition at Cornell, USAID/S&T and AID/E.

2. Ecuador: New project activities allowed INIAP to collaborate with the Regional Development Program in Manabi and with the Integrated Pest Management Project (University of Illinois), the Peace Corps and CARE in Pimampiro. Contacts were also initiated with Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) and IITA.

   The project was instrumental in getting INIAP collaborators invited on outside funds to attend the Farming Systems Research Symposium at Kansas State in November 1983 and to receive training in MSTAT at Michigan State in spring 1984, thereby linking INIAP more effectively with the Farming System Support Project. The project plans to maintain these contacts by underwriting English-Spanish translation at the 1984 Farming Systems Research Symposium, inviting INIAP and Instituto de Ciencias y Tecnologia Agricola (ICTA) investigators to attend the conference and then holding collaborative work sessions at Cornell. Finally, the project has begun negotiations to publish its research as a book in Ecuador.

B. On-Going Linkages

1. United States: Contact has been maintained with the University of Florida's Rural Technology Transfer System Program and with the Farming Systems Support Project, both on campus and in Florida.

2. Ecuador: For project activities, INIAP has obtained information and collaboration from several national institutions, including the Agrarian Reform Agency, Institute of Meterology, National Program in Agrarian Regionalization, Census Bureau and Internal Revenue. INIAP maintains contact with CIAT, FAO, Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) and Centro Agrónomico Tropical de Investigación y Enseñanza (CATIE).

XII. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy

1. United States: The overall plan of work emphasizes activities in Ecuador. This is made necessary by a current budget allocation that is inadequate to support field activities in Ecuador and active sociological research and development activities at Cornell. Accordingly, the on-campus objective is to revise several working papers and submit them for publication. Work will continue on the applications of microcomputers to

farming systems research, provided that access to the appropriate hardware and software can be negotiated. Work on incorporating nutritional outcomes, especially as baseline data for agricultural projects, will continue.

2. Ecuador: Major objectives are to improve research conducted by the Legume Program, Socio-Economic Support Unit and the Program in Production (PIP) and to continue research on varieties, planting distances and fertilization at Pimampiro. New research on seed improvement and seed deterioration will be initiated in Pimampiro, and diagnostic research will begin in Manabi.

   Legume Program/Socio-Economic Units: A basic objective is to assist INIAP in improving its ability to evaluate experiments and to use these skills in the design of future research. The field agronomist, Dr. Kline, will work with INIAP to establish goals for breeding and agronomic activities. Within this context, Dr. Kline will help the Legume Program incorporate physiological-genetic issues, specifically by temperature. An objective is to begin breeding of better-adapted, disease resistant and commercially acceptable bean cultivars while continuing to evaluate CIAT's lines.

   Dr. Kline will combine informal collaboration with formal working seminars where work is reviewed and new approaches are considered. The sociologist, Dr. Uquillas, will participate in all formal sessions and in appropriate informal meetings. He will make contributions to research design and statistical analysis, microcomputer applications and the socio-economic evaluation of technologies. He will also work closely with the Socio-Economic Unit and PIP program staff to improve the conduct of research. Project staff will work with INIAP to improve communication with farmers in order to elicit more farmer involvement in field trials, to explain research results within the farm community and to establish communication from farmer back to researcher.

   Pimampiro: A principal objective is the diagnosis of postharvest problems and the design of research on storage and on-farm seed production. Structured interviews will be developed, and research will focus on: sources of seed, with special attention to the exchange or purchase of seed from ecologically different regions; storage practices; and the timing, magnitude and perceived seriousness of postharvest losses. The team will interview in small groups, prepare a working paper and specify researchable issues for postharvest loss and on-farm seed production.

   The experimentation begun this year concerning fertilizer, spacing and varieties will continue, taking into account 1984 results and recommendations for improvements in the basic research design. The FAO-sponsored/INIAP-initiated "Learn by Doing" course on beans will be evaluated to improve such courses in the future.

Manabí: The objective for initial work here is to analyze smallholders' activities in two areas served by the Portoviejo experiment station. Regional analysis (Garrett and Goldstein, 1984) will permit evaluation of research priorities in light of smallholders' ascertained needs. It will also permit investigators to determine whether future research on legumes is appropriate in this region. Germplasm necessary to conduct further research is currently being multiplied.

Multi-disciplinary team building will be emphasized. Special attention will be paid to the process by which diagnostic field research is translated into a problem amenable to experimentation. An objective is to learn exactly how pre-intervention farming systems research identifies researchable problems so that the process can be replicated in other zones and by other institutions.

Activities in all zones will be conducted collaboratively, emphasizing the importance of establishing multi-disciplinary teams and sharing experiences through working papers. INIAP counterparts for each project activity have been identified, and a calendar has been developed which corresponds to each zone's work plan.

B. Training Objectives and Strategy

1. United States: One female agronomist (Ms. J. Hall) will be supported to conduct research on seed deterioration in Pimampiro. She explored problems in the field during August 1984 so that she could prepare prior to leaving in January 1985 to conduct field research.

2. Ecuador: A major responsibility of both US staff members is to develop and implement in-house seminars to improve INIAP's research ability. The seminars will focus on critical methodological issues, interrelate project activities in different regions and encourage scientists to write working papers to share information with others.

   Dr. Uquillas and three INIAP counterparts will attend the Farming Systems Research Symposium at Kansas State University, October 1984. Following this, they will exchange experiences with ICTA counterparts and work with project staff at Cornell.

C. Anticipated Personnel/Locational Changes: Two additional Cornell faculty members have become co-investigators. Dr. H. Chris Wien, Department of Vegetable Crops, has rejoined the project, bringing specific expertise on cowpeas, experimental design and the study of competition in intercropping. Dr. David Thurston, Department of Plant Pathology, has joined the project to work on problems of integrated pest management. Dr. Thurston speaks fluent Spanish as a result of several years work in Latin America. Both investigators are heavily involved in farming systems research.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Arévalo, Venus. 1983. Informe Preliminar de la Encuesta sobre la Producción de Fréjol en la Zona de Pimampiro en Imbabura. Bean/Cowpea CRSP Ecuador Project Working Paper 83.1S. Ithaca, NY: Cornell University, International Agriculture Program, October.

Barril, Alex. 1983. El crédito agropecuario en el Ecuador: Antecedentes y comentarios sobre el acceso al sector campesino. Manuscript. Ecuador: Centro Sur de Desarrollo Agropecuario (CEPLAES).

_____. 1983. El crédito agropecuario en el Ecuador y su acceso al sector campesino: Estudio de caso en el Canton Pimampiro, Provincia de Imbabura. Ecuador: Centro Sur de Desarrollo Agropecuario.

Barsky, Osvaldo. 1983. Estudio de los procesos de mercado y comercialización de fréjol en la zona de Pimampiro, Ecuador. Manuscript. Ecuador: Centro Sur de Desarrollo Agropecuario.

_____. 1983. Información Estadística sobre la producción de leguminosas y de fréjol en Ecuador. Manuscript. Ecuador: Centro Sur de Desarrollo Agropecuario.

Espinosa, Patricio. 1983. Informal Presentation of the INIAP/Cornell University Farming Systems Activities at the Farming Systems Research Symposium, Kansas State University, Manhattan, KS, November 1983.

Francis, Joe D., Richard J. Harris and Dan E. Moore. 1984. Some Methodological Considerations in Studying Inequality. Bean/Cowpea CRSP Ecuador Project Working Paper 84.5E. Ithaca, NY: Cornell University, International Agriculture Program, July. Available in Spanish as Bean/Cowpea CRSP Ecuador Project Working Paper 84.5S.

Garrett, Patricia. 1984. Appropriate Technology for Smallholders: Some Implications of Social Stratification for Farming Systems Research. Bean/Cowpea CRSP Ecuador Project Working Paper 84.1E. Ithaca, NY: Cornell University, International Agriculture Program, February. Available in Spanish as Bean/Cowpea CRSP Ecuador Project Working Paper 84.1S.

_____. 1984. Agricultural Research and Development: Viable Objectives for Smallholders. Bean/Cowpea CRSP Ecuador Project Working Paper 84.6E. Ithaca, NY: Cornell University, International Agriculture Program, April. Available in Spanish as Bean/Cowpea CRSP Ecuador Project Working Paper 84.6S.

_____. 1984. Bean/Cowpea CRSP Ecuador Project Activities. Presentation at the pan-CRSP session, Rural Sociological Association Meetings, San Antonio, TX, August 1984.

_____. 1984. Report on Bean/Cowpea CRSP Activities in Ecuador. Presented to emeritus faculty, Cornell University, spring 1984.

_____. 1983. Methodological Issues in Farming Systems Research. Farming Systems Research Symposium, Kansas State University, November 1983.

_____. 1983. Methodological Issues in Farming Systems Research. Presentation to the Farming Systems Research Seminar, International Agriculture Program, Cornell University.

Garrett, Patricia and Donna Goldstein. 1984. Some Methodological Issues in Pre-intervention Farming Systems Research: Selecting Appropriate Techniques for Data Collection. Bean/Cowpea CRSP Ecuador Project Working Paper 84.4E. Ithaca, NY: Cornell University, International Agriculture Program, June. Available in Spanish as Bean/Cowpea CRSP Ecuador Project Working Paper 84.4S.

Golden, David. 1983. Program to Calculate Gini Coefficients: Microsoft Basic Compatible, Designed for Apple II CP/m. Bean/Cowpea CRSP Ecuador Project Working Paper 83.3E. Ithaca, NY: Cornell University, International Agriculture Program, October.

Goldstein, Donna. 1984. Sharecropping and Accumulation in the Northern Ecuadorian Sierra. Bean/Cowpea CRSP Ecuador Project Working Paper 84.3E. Ithaca, NY: Cornell University, International Agriculture Program, February. Available in Spanish as CRSP Bean/Cowpea CRSP Ecuador Project Working Paper 84.3S.

Palacios, Juan y Patricia Garrett. 1984. Estructura de la Producción-Agropecuaria en la Provincia de Imbabura: Un Análisis Estadístico. Bean/Cowpea CRSP Ecuador Project Working Paper 83.2S. Ithaca, NY: Cornell University, International Agriculture Program, February.

_____. 1983. Guía Básica para el Análisis de Información Censal Agropecuaria. Bean/Cowpea CRSP Ecuador Project Working Paper 83.2S. Ithaca, NY: Cornell University, International Agriculture Program, Octubre.

Wallace, D. H., R. F. Sandsted and H. R. Capener. 1984. Report on Bean/Cowpea CRSP Activities in Ecuador and Guatemala. Workshop presented to bean researchers, Cornell University, May 1984.

Wallace, D. H., R. F. Sandsted, H. R. Capener and P. Garrett. 1983. Report on Bean/Cowpea CRSP Activities in Ecuador and Guatemala. Presentation to a joint International Agriculture Program and Department of Plant Breeding Seminar, Cornell University, spring 1984.

GUATEMALA • CORNELL UNIVERSITY

Agronomic, Sociological and Genetic Aspects of Bean Yield and Adaptation

I. PROJECT ROSTER

A. US Lead Institution: Cornell University (CU)

Principal Investigator:	Dr. Donald H. Wallace, Department of Plant Breeding and Biometry, CU
Co-Principal Investigators:	Dr. Harold R. Capener, Department of Rural Sociology, CU Dr. Patricia Garrett, Department of Rural Sociology, CU Dr. Roger F. Sandsted, Department of Vegetable Crops, CU
Research Associates:	Dr. Patricia Netherly, International Agriculture Program, CU Dr. Carlos Gonzáles-Peralta, International Agriculture Program, CU
Field Trial Manager:	Mr. Bruce Rich, Department of Plant Breeding and Biometry, CU
Program Coordinator:	Mr. Larry Zuidema, Associate Director, International Agriculture Program, CU
Assistant Program Coordinator:	Ms. Linda Russo, International Agriculture Program, CU
Secretary:	Ms. Reina Walther, International Agriculture Program and Department of Plant Breeding, CU
Accountant:	Ms. Mary Neff, International Agriculture Program, CU
Contracts and Grants Officer:	Mr. Don K. Enichen, Office of Sponsored Programs, CU
Institutional Representative:	Dr. Edwin Oyer, Director, International Agriculture Program, CU

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

Principal Investigator:	Dr. Porfirio Masaya, Bean Program Leader, ICTA
Co-Principal Investigator:	Lic. Selvin Arriaga, Head, Socio-Economic Program, ICTA
Agronomist:	Ing. Armando Monterroso, Bean Program, ICTA
Agricultural Economist:	Lic. Mamerto Reyes, Socio-Economic Program, ICTA
Administrator:	Ing. Astolfo Fumagali, Executive Director, ICTA
Biometrician:	Ing. Juan Manuel Herrera, Statistician, ICTA

C. USAID Project Officer: Mr. Harry Wing, Chief, Office of Rural Development, USAID/Guatemala

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives

1. Integrated research on farming systems

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.

2. Research on genetic and environmental control of maturity and adaptation

a. Determine how the several variations of climate affect the adaptation, growth and yield of beans.

b. Identify the genes that facilitate adaptation, growth and higher yield in different environments.

c. Explore the merits of new combinations of these genes for maximizing adaptation, growth and yield in different environments.

Seven complex and specific objectives about daylength x temperature x genotype effects upon maturity, adaptation and yield were listed under this general objective. They are not re-listed here because of their complexity and specificity. Sufficient progress (Wallace, Masaya and Gniffke, 1984; Wallace, in press; Bean/Cowpea CRSP 1983 Annual Report: Technical Summary and 1984 Detailed Annual Report) has been made that current emphasis is upon applying the findings to 2.c above, in which breeding of better-adapted, higher-yielding cultivars is being undertaken.

B. FY 84 Objectives

1. Initiate the processes of incorporating the socio-economic and agronomic with the genetic variables in order to encompass the inter-disciplinary components of farming systems research.

2. Develop theoretical and methodological procedures which will be appropriate and feasible under current field conditions for farming systems research.

III. CHANGE IN FY 84 OBJECTIVES

The following specific objectives were added:

A. Examine the degree to which past farm trial and field test plots' locations are representative of the broader universe of small farms and soil types.

B. Obtain a greater systems-level understanding of the farming world as perceived by the selected small-scale farming families.

C. Structurally and functionally involve other organizational, institutional and/or agency programs that can combine and assist in achieving the broader national agricultural development goals.

D. Begin application of the physiological-genetic findings to bean breeding.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

Constraints having to do with transferring funds, timeliness of budget decisions and coordinated planning were overcome and now permit program progress.

V. PROGRESS TOWARD OBJECTIVES

Significant steps were taken to interface the socio-economic, agronomic and genetic variables in the research agenda. These include:

A. An organizational advance was made when the ICTA administration transferred the socio-economic testing team back under the research director, who also administers activities of the field technology testing team which conducts the agronomic field trials, and the bean program which emphasizes breeding. This permits a more holistic and systems approach. It enhances the inter-disciplinary and inter-commodity perspective that is essential to a farming systems analysis.

B. ICTA staff activities have expanded. At the project's inception, the genetic component conducted by the bean program was the principal on-going activity. Starting in January 1984, four people from the socio-economic team and six from the technology testing team of the Chimaltenango region became active. These ICTA units work to facilitate multi-disciplinary implementation of the project's genetic, socio-economic and agronomic components in its farming systems research. The newly added units have implemented, and continue to implement, ICTA's socio-economic and farming systems activities. They simultaneously do the same for project objectives. This operationalizes the multi-disciplinary feature required for the project's farming systems research objectives.

C. The incorporation of the socio-economic and agronomic activities has quadrupled the number of ICTA employees working with the project. It simultaneously quadruples matters of planning, coordination, communication, training and logistical support, but it also quadruples the output that can be expected. This illustrates generous support by ICTA's central administration, under which the bean program and the socio-economic team work, and by the Chimaltenango region, under which the technology testing team works. CRSP support is sustaining project-related ongoing ICTA field trials, most specifically, travel and logistic support for obtaining economic, agronomic and genetic data.

D. ICTA has assigned two new, capable, supervisory personnel to the project. The ICTA administration has expanded project activities by assigning two staff members, at 80 percent of their time, to work on the project's objectives. Ing. Armando Monterroso was assigned to the bean program with responsibility for planning and supervising the agronomic components of the field trials which are jointly carried out by the technology testing team. Lic. Mamerto Reyes was assigned to plan and to supervise the socio-economic team.

E. The issue of representativeness is being addressed. Key questions of theoretical and methodological significance raised by Dr. Patricia Garrett in the Ecuador Bean/Cowpea CRSP farming systems project are: What is known about farm families, their farming systems and their place and fit in the universe of farmers in the region? These questions were of significance to the ICTA staff. When Inter-American Bank officials asked if their field trials were too near the well-established roads, there was insufficient documentation to verify representativeness of the farms selected of the total farms in the region. The most efficient method in time and cost for examining representativeness was judged to be primary and secondary data analysis.

F. The information available from ICTA-sponsored field trials and test plots in farmers' fields from 1975 to 1983 represents an important database for analysis. In addition, some thirty-six field trial experiments for 1984 are available for additive and comparative analysis. These records contain information on cropping practices and farming methods used on small farms. Most of the agronomic searching out, classifying and selecting dealt with variety trials, comparing newly available, improved cultivars with traditional farmers' varieties. Ing. Monterroso is assembling this information for beans and for other crops, including corn, potatoes, wheat and selected vegetables.

G. An activity undertaken by the new agronomist working with the project, Ing. Armando Monterroso, is the identification of homogeneous areas within the study sites of the region. The variables being examined are the soil types, life zones and information on temperature, elevation and precipitation.

His investigations have revealed that there are several common farming systems which spread across presumedly homogeneous areas. One explanation for this is that there is more unidentified soil

variation within presumedly homogeneous areas than was previously supposed. This finding signals that searching out, identifying and classifying homogeneous zones should receive high priority for greater precision in selecting representative farm trial sites.

Maps developed from overlaying life zone maps on soil maps are being used to stratify future agronomic and socio-economic work between and among the different homogeneous areas. Pinpointing the locations of previously conducted farm trials on the maps will indicate where prior work was done and will guide future representation.

H. The new economist, Lic. Mamerto Reyes, is carrying out in-depth analysis of the farm records from the 1982-83 field trials. Available data include cultural practices, cropping patterns, soil tests, fertilizer applications, size of units, labor inputs of men, women and children and disposition toward adoption of new, recommended varieties.

One finding is that farmers do not plant beans following cabbage. It was learned from farmers that the decaying cabbages left spores and/or chemicals in the soil which reduced bean yields. This illustrates the validity of indigenous farmers' knowledge.

I. From the Cornell side, a new research associate, Dr. Carlos Gonzáles, will be employed and stationed in Guatemala City. Dr. Gonzáles will expand the analyses and examine the scope and methodological alternatives for analyzing the various primary and secondary resources. He will work with Lic. Selvin Arriaga and Lic. Mamerto Reyes.

J. Dr. Patricia Netherly was hired as a consultant for six months, March to September 1984. Dr. Netherly is an anthropologist with considerable working experience in Peru and Ecuador. She helped to identify and give shape to several components of the plan of work, the proposed training and the aerial photographic interpretation. A position paper prepared by Dr. Netherly will serve as a guide to the project. The title of the soon-to-be completed work is Report on Agriculture in the Chimaltenango Region and Its Relevance to the Bean/Cowpea CRSP.

K. Genetic progress includes making crosses and growing seed of segregating generations for 1985 research objectives (see Work Plan, Section XII.A.2).

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use: Final preparation for publication of a literature review demonstrates that the photoperiod x temperature x genotype interactions shown to control maturity, adaptation and consequent yield in beans also function in most, if not all, crop species (Wallace, in press). The review presents such evidence from twenty-five crops and has been of assistance in formulating the interpretations of beans.

The merit of applying the concept in plant breeding is demonstrated by the pending release in New York state of an early-maturing, photoperiod/temperature-insensitive, red kidney line that over five

years has yielded 20 percent more per land area per growing season than the standard late-maturing cultivar. With respect to biological efficiency, this is 43 percent more economic product per unit of land area per day of plant growth.

B. Available for Use Within One or Two Years

1. The current techniques and methodologies being explored and employed which use available primary and secondary data will add to the knowledge base for farming systems research. Microcomputer-assisted data collection, analysis, interpretation and publication will contribute to the empirical body of knowledge about farming systems.

2. Dr. Netherly's paper.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
Gniffke	M	Cornell	Plant Breed.	Ph.D.		Total
Yourstone	M	Cornell	Plant Breed.	Ph.D.		None
Guatemala Citizens:						
Aldana	M	Cornell	Plant Breed.	M.S.		Total
Others:						
None						

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
Yourstone	M	Cornell	MSTAT Wkshp.	MSU	One week
Guatemala Citizens:					
Masaya	M	ICTA	MSTAT Wkshp.	MSU	One week
Herrera	M	ICTA	MSTAT Wkshp.	MSU	One week
Others:					
None					

VIII. BASELINE DATA

Investigation of primary and secondary data pertinent to the CRSP project in the Chimaltenango region is about midway to completion. Data include soil maps, hydrologic records, contour maps, agricultural production records, census information, aerial photographic information

and extensive field trial and test plot results from ICTA's research efforts on farmers' fields.

Parallel work in the same region by a USAID-sponsored project on farming diversification has produced a sectorial analysis report by a Guatemalan anthropologist, Lic. Danellio Palma. This report is now available at USAID/Guatemala.

IX. WOMEN IN DEVELOPMENT

Socio-economic records on ICTA's farm trials, compiled during 1975-1984, contain information on labor inputs of farm women and children. These records will be analyzed to determine the role of women and family members in the production process.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO THE PROJECT

A. United States

Cornell's contribution is primarily in the area of personnel:

Dr. Donald H. Wallace, professor, 20 percent
Dr. Patricia Garrett, assistant professor, 15 percent
Dr. Harold R. Capener, professor, 10 percent
Dr. Roger Sandsted, professor, 10 percent
Mr. Larry Zuidema, Associate Director, International Agriculture, 5 percent
Ms. Mary J. Neff, accountant, 6.5 percent
Mr. Bruce Rich, field manager, 29 percent
Ms. Reina Walther, secretary, 5 percent

Contributed salaries	$25,236
Contributed fringes	6,182
Contributed indirect	14,116

B. Guatemala

ICTA contributes substantially in personnel, field plots, research and office facilities. At this point, the total contribution is not available. Time contributed by ICTA personnel:

Dr. Porfirio Masaya, director, bean program, 50 percent
Lic. Selvin Arriaga, director, socio-economic unit, 50 percent
Lic. Mamerto Reyes, economist, 80 percent
Ing. Armando Monterroso, agronomist, 80 percent
Ing. Astolfo Fumagali, executive director, 10 percent
Ing. Juan Manuel Herrera, statistics, 30 percent
About 8 other technicians also contribute.

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New informal linkages for the farming systems component of the project are:

1. United States

   a. Contact was established with the Cornell farming systems research and training program for the Philippines in the area of research methodology.

   b. Contact was established with the Farming Systems Support Program.

   c. Efforts are being made to coordinate research with the INCAP/Washington State University Bean/Cowpea CRSP project.

   d. The project's physiological-genetic studies are coordinated with CIAT.

2. Guatemala

   a. The USAID program on farming diversification has agreed that the project and the CRSP should communicate and exchange reports.

   b. On-going conversations to define mutual research topics are being held with INCAP.

   c. A relationship is being established with Raphael Landivar University's Institute of Agriculture and Environmental Sciences for farming systems research.

B. On-Going Linkages

1. United States

   a. The Western Regional Project W150 links virtually all bean improvement projects in the US.

   b. The biennial Bean Improvement Cooperative meeting and annual report links most bean research projects on an international basis.

2. Guatemala: ICTA's activities are closely linked with CIAT for breeding and socio-agronomic activities.

XII. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy

1. United States

   a. Objectives

      (1) Continue working through the complex processes of inter-disciplinary understanding and cooperation, in order to encompass the variables involved in farming systems research.

(2) Develop theoretical and methodological procedures which are appropriate and feasible for conducting farming systems research under current field conditions.

(3) Learn the inheritance of the photoperiod-temperature sensitivity of Redkloud vs. the very high sensitivity of the El Salvadoran variety Rojo 70 in the growth chamber and field and study its linkage to the gene controlling determinate vs. indeterminate habit.

b. Strategy: The strategy for implementing the above objectives is to mobilize an inter-disciplinary project team to identify the key variables in farming systems research and the theoretical and methodological procedures that can be developed and implemented in collaboration with Guatemalan counterparts.

2. Guatemala

a. Farming Sy:

(1) Farming Systems Objectives

(a) Identify the optimum field locations where on-farm social, economic, agronomic and plant biological activities can best yield recommendations for farming practices and appropriate technology transfer.

(b) Obtain a greater systems-level understanding of the farming world as perceived by small-scale farming families.

(c) Assist ICTA in correlating sets of appropriate technological practices for small-scale farming households that will increase overall production and relative family well-being.

(d) Involve other organizational, institutional and/or agency programs as they can assist in achieving the broader national agricultural development goals.

(2) Farming Systems Strategy: The strategy for implementing the above objectives is to undertake collaboratively an extensive diagnostic procedure using primary and secondary data to identify homogeneous areas, ecological zones and targets of opportunity for advancing farming systems research. It is necessary to train ICTA staff, obtain selected computer analysis capability and initiate a process of distilling, documenting and producing written materials that will contribute to empirical knowledge about indigenous farming systems. An important component will be post-

ing the Cornell research associate, Dr. Carlos Gonzáles, in Guatemala City to work directly with ICTA staff.

b. Physiological-genetic research strategy

(1) In 1984, production of F_1 and F_2 generation seed of five crosses among climbing bean genotypes provided F_2 seed to be grown in 1985. These will be selected for maximized adaptation and yield and genetically studied for inheritance of architectural, phenological and maturity characteristics (see (2) below) that make the bean genotypes adapted or unadapted to the agricultural systems used in the Guatemalan central highlands.

(2) Seed of the F_2 generation of all twelve possible crosses among four Guatemalan bush bean cultivars with contrasting flowering responses was planted at 50 m (29°C mean temperature), 895 m (24°C) and 1786 m (19°C), all on May 23, 1984 to give the same daylength. Data collection was completed in the two warmer locations but requires up to nine months for the coolest. Data for each plant will be analyzed to give inheritance patterns and temperature effects on twelve characteristics that make the plants adapted or unadapted: (1) days to flowering, (2) node of first flower, (3) stem diameter, (4) total node number, (5) days to physiological maturity, (6) number of nodes on branches, (7) number of nodes on main stem, (8) number of nodes on primary, secondary and tertiary branches, (9) total weight and (10) seed weight.

(3) Germplasm known to be sensitive (check varieties) or believed insensitive to daylength and high temperature and, therefore, adapted to the tropical lowlands was grown in 1984 at the fifty meter location. It was tested for web blight resistance, which is essential for lowland adaptation. An October 1984 planting of the best adapted of 192 tested lines will identify superior parents for breeding improved lowland-adapted cultivars.

B. Training Objectives and Strategy

1. United States

a. Discover and share techniques of procuring and analyzing primary and secondary data.

b. In working with small-scale farmers, learn more about how to listen and how to ask the right questions.

2. Guatemala

a. Improve capabilities of ICTA project personnel working with Cornell personnel to accomplish the following:

(1) Achieve extensive primary and secondary data analysis concerned with characterization of homogeneous areas, ecological zones and sampling representation.

(2) Train ICTA staff in techniques of aerial photographic interpretation.

b. Train ICTA staff through developing working seminars and other means of data interpretation. Encourage reflection on ICTA's extensive field experience so that project personnel become better listeners and questioners.

c. Utilize advisers from the Cornell farming systems training program and other sources to help establish and maintain high standards regarding the value, significance and contribution of the farming systems research.

d. Train ICTA staff via working seminars to identify, record and document their extensive empirical experience in working with farmers in commodity and cropping field trials and test plots.

e. Train the ICTA staff to distill the information and expertise of items (a) through (d) above into principles, strategies and development activities that will help to achieve the overall objectives.

C. Anticipated Personnel/Location Changes

1. Dr. Carlos Gonzales-Peralta of Cornell will be stationed in Guatemala City from January to September 1985.

2. Lic. Armando Monterroso will come to Cornell in April 1985 to pursue a Ph.D. program in agronomy and farming systems.

3. After finishing an M.S. in plant breeding, Mr. Fernando Aldana will return to Guatemala to concentrate on breeding beans for blight resistance.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Gniffke, P. A. 1984. Linkage Between a Gene Controlling Growth Habit and One Controlling Photoperiod Sensitivity in a Bean (Phaseolus vulgaris L.) Cross Grown Under Long Daylengths. Manuscript. Department of Plant Breeding, Cornell University.

Masaya, P. N. and D. H. Wallace. 1984. Photoperiod-Temperature Modulation of Genetic Control Over Apical Dominance for Reproductive Growth in Determinate Bean (Phaseolus vulgaris L.). Manuscript. Department of Plant Breeding, Cornell University.

_____. 1984. A Two-Gene Model for and Photoperiod-Temperature Modulations Over Gene Actions Regulating Days to Flower in Bean (Phaseolus vulgaris L.). Manuscript. Department of Plant Breeding, Cornell University.

_____. 1984. Aggressiveness of Climbing Bean is Correlated with Characteristics of Maturity. Bean Improvement Cooperative Annual Report, 27:198-199. Also presented to the Bean Improvement Cooperative meeting, Minneapolis, MN, November 7-10, 1983.

_____. 1984. The Effect of Elevation (Temperature) on Number of Days to and Node of Flowering in Beans. Bean Improvment Cooperative Annual Report, 27:199-202. Also presented to the Bean Improvement Cooperative meeting, Minneapolis, MN, November 7-10, 1983.

More, T. A., A. F. H. Muhammad, K. S. Yourstone and D. H. Wallace. 1984. Effects in Bean of Diurnal Temperature Difference Plus Mean Temperature on Days to Flower and on Developmental Stage of Flower Bud Aborted Under Delaying and Non-Delaying Photoperiods. Manuscript. Department of Plant Breeding, Cornell University.

Wallace, D. H. In press. Physiological Genetics of Maturity, Adaptation and Yield. Plant Breeding Review.

Wallace, D. H., R. F. Sandsted and H. R. Capener. 1984. Report on Bean/Cowpea CRSP Activities in Ecuador and Guatemala. Workshop presented to bean researchers, Cornell University, May 1984.

Wallace, D. H., R. F. Sandsted, P. Garrett and H. R. Capener. 1984. Report on Bean/Cowpea CRSP Activities in Ecuador and Guatemala. Presented to Department of Plant Breeding, Cornell University, May 1984.

Wallace, D. H., P. N. Masaya and P. A. Gniffke. 1984. Temperature x Photoperiod, Adaptation and Yield in Phaseolus vulgaris. Vanguard I(1). East Lansing, MI: Michigan State University, Bean/Cowpea CRSP Management Office.

HONDURAS • UNIVERSITY OF PUERTO RICO

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. James S. Beaver, Department of Agronomy, UPR
Co-Principal Investigator:	Dr. George F. Freytag, Tropical Agriculture Research Station (TARS), US Department of Agriculture-Agricultural Research Station (USDA-ARS), Mayagüez, PR
Investigators:	Ms. Mildred Zapata-Serrano, Department of Crop Protection, UPR
	Mr. Rodrigo Echávez-Badel, Department of Crop Protection, UPR
Research Assistant:	Mr. Luis E. Rivera, Department of Agronomy, UPR
Technicians:	Mr. Hirám Vélez-Martínez, Department of Crop Protection, UPR
	Mr. Samuel Carcamo, Department of Crop Protection, UPR
Controller:	Mr. Jaime Hernandez-Vega, Finance Officer, UPR
Secretaries:	Ms. Hilda J. Carrero, Department of Crop Protection, UPR
	Ms. María Pagan, Department of Crop Protection, UPR
Institutional Representative:	Ing. Miguel González-Román, Sub-Director, Agricultural Experiment Station, UPR

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

Principal Investigator:**	Ing. Rafael Diaz-Donaire, Department of Agronomy, EAP
Co-Principal Investigator:	Dr. Jorge Chang, Head, Department of Agronomy, EAP
Agronomist:	Mr. Luis del Río, Department of Agronomy, EAP
Technicians:	Mr. Pablo Rucks, Department of Agronomy, EAP
	Mr. Johnathan Cerna, Department of Agronomy, EAP

*Dr. James Beaver replaced Dr. Julio López-Rosa as PI in May 1984.
**Ing. Diaz replaced Dr. Carlos Pineda as PI in March 1984.

Technicians cont'd.	Ms. Marjorie Mayr, Department of Agronomy, EAP
	Ms. Denie Espinal, Department of Agronomy, EAP
Secretary:	Ms. Isabel Alvarez, Department of Agronomy, EAP
Controller:	Mr. Frederico Fiallos, Department of Administration, EAP

C. USAID Project Officers: Mr. Stephen Wingert, USAID/Honduras
Mr. Brian Ruder, USAID/Honduras

II. PROJECT OBJECTIVES

A. Produce multiple disease resistant bean germplasm in order to reduce losses due to diseases and increase yield stability of beans in Honduras.

B. Preserve or improve the agronomic characteristics, yield and quality of bean varieties having the preferred seed type for Honduras in order to assure the efficient production of a crop that will meet the acceptance and fulfill the nutritional requirements of the population.

III. CHANGE IN FY 1984 OBJECTIVES

No changes in objectives were made.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Puerto Rico

1. The lack of adequate transportation has limited travel to research substations at Isabela, Limani and Fortuna.

2. A rust race virulent to the B-190 source of genetic resistance appeared at the Isabela substation. Tests also have found rust races in Honduras that are virulent to the B-190 source of resistance. New, more stable sources of genetic resistance to rust will need to be identified and incorporated into the breeding program.

B. Honduras

1. The project has submitted purchase requests for a vehicle and several items of equipment. However, it did not receive approval to purchase any major item of equipment during FY 84. These delays have reduced research capabilities and have interrupted the projected spending pattern.

2. It has been difficult to identify candidates for graduate training. Graduates from EAP require approximately two years of additional studies to complete a B.S. at UPR. A B.S. degree can be completed in one to two years at other universities such as the University of Florida, which has a history of training

EAP graduates. Employees at the Ministry of Natural Resources with B.S. degrees are reluctant to continue studies due to the lack of financial incentives for those employees with advanced degrees.

3. The project had been troubled by a high rate of turnover at the Host Country (HC) Principal Investigator (PI) level. This problem has been solved, however, with the appointment of Ing. Rafael Diaz as PI. During the last six months, Ing. Diaz has provided the leadership needed to revitalize project activities in Honduras. As a former employee of the Ministry of Natural Resources, Ing. Diaz has improved communication among bean researchers in Honduras.

4. Slugs are a very serious bean pest in certain regions of Honduras. Effective control methods need to be developed in the affected regions. An AID-supported project based at EAP is addressing this problem.

V. PROGRESS TOWARD PROJECT OBJECTIVES

A. Puerto Rico

1. Germplasm from the US and CIAT was evaluated for adaptation and disease resistance. Trials from CIAT included an international bean rust nursery, a bacterial blight nursery, an international flowering and adaptation nursery, an adaptation nursery containing two hundred fifty promising lines for the Caribbean islands and four preliminary yield trials. Germplasm from the US was evaluated in a national rust nursery and two root rot nurseries.

2. Crossing blocks were planted at the Isabela substation in October and February. A series of crosses and backcrosses was made between genotypes having the Zamorano seed class and different sources of disease resistance.

3. A nursery containing F_3 lines derived from crosses between sources of rust and bacterial blight resistance was evaluated at the Isabela substation for adaptation and rust resistance. The most promising lines were selected and grown in an F_4 nursery in order to evaluate the material for adaptation and bacterial blight resistance.

4. Advanced line yield trials were conducted at the Isabela and Fortuna substations. Genotypes 8241-372 yielded well and had low levels of infection to rust and bacterial blight. These lines have been sent to Honduras for further testing.

5. Single pustule isolates of a rust race virulent to the B-190 source of genetic resistance were obtained at the Isabela substation. These isolates were sent to USDA-ARS plant pathologist, Dr. J. R. Stavley, in order to study their virulence when tested on a differential set of bean genotypes.

6. Field observations were made at the Fortuna and Isabela substations on plots located near sources of inoculum of rust in order to study the nature of survival of rust during the hot and humid summer months. Urediospores were germinated to estimate survival of the pathogen.

7. Selected clones of Phaseolus coccineus with multiple virus resistance, bean golden mosaic virus (BGMV), bean common mosaic virus (BCMV), cowpea mosaic virus (CPMV) and common blight resistance were crossed and tested under greenhouse conditions for virus symptom expression. Resistant and susceptible lines were determined by systemic and latent infection for BCMV. The resistance to BGMV appeared to be lost since no resistant hybrids were observed in the greenhouse. Under field conditions, however, viruses and common blight caused only low levels of damage.

8. Phaseolus coccineus germplasm identified as a good source of multiple virus resistance was used for breeding purposes in order to attempt to transfer the resistance to P. vulgaris lines. P. vulgaris was used as the female and P. coccineus was used as the male parent. Twenty interspecific hybrids were propagated by stem cuttings. Response to inoculation with a necrotic BCMV isolate was studied in the F_1 generation. Approximately 50 percent of the F_1 plants showed necrotic symptoms and the other plants were resistant. Morphological abnormalities on some interspecific hybrids were observed. In order to determine if the abnormalities were induced by an infectious agent or a cytoplasmic effect, reciprocal grafts were performed. The survival and development of P. coccineus scions on interspecific hybrid stock were normal. In contrast, when P. coccineus was used as stock and the interspecific hybrids as scions, an antagonistic effect was shown by necrosis of the scion and stock branches.

9. Evaluation of populations developed from crosses between sources of recessive gene resistance for BCMV and a group of P. vulgaris advanced lines with unprotected "I" gene resistance to BCMV was conducted under greenhouse conditions. Two crosses gave total protection to the necrotic isolate of the BCMV. This material will be tested under field conditions for adaptation and will be used as a source of resistance to BCMV in the crossing program.

10. A P. coccineus necrotic virus isolate of BCMV was evaluated under controlled conditions at 20°C and under greenhouse conditions. Necrosis developed on host groups 1, 4 and 9. No symptoms were observed on host groups 2, 3, 6, 7, 8 and 10. This necrotic virus isolate seems to be different in reaction to previously described strains of BCMV.

11. Selected lines of Phaseolus acutifolius were inoculated under greenhouse conditions with a virulent strain of Xanthomonas campestris pv. phaseoli. Seed of the most resistant lines was harvested and sent to researchers in the US. This germplasm

should be useful in the improvement of P. acutifolius populations and in interspecific crosses as a source of bacterial blight resistance.

12. Forty-seven isolates of Xanthomonas campestris pv. phaseoli were tested for pathogenicity on leaves in the greenhouse and on pods in an environmental chamber. The isolates showed more virulence on leaves than pods. Additional information was obtained for each isolate by the gram test, cell form, reaction on differential media and serological tests.

B. Honduras

1. A trial designed to estimate the economic loss to rust was conducted at three locations. Since these trials contained both susceptible and resistant bean germplasm, the economic value of different sources of genetic resistance to rust also was estimated.

2. A group of bean varieties collected from small farms by Ing. Rafael Diaz was evaluated for adaptation and disease resistance at EAP. Fifty of the most promising lines were selected and tested at three locations. Seed of all of these lines will be stored in the EAP germplasm bank.

3. A large number of trials have been established on small farms in the Danli and Olancho departments. These trials were designed to measure the adaptation and disease resistance of promising bean genotypes and to monitor the frequency and intensity of bean diseases.

4. A group of red-seeded lines developed from crosses made by Dr. Pablo Paz was evaluated at three locations. Some of these lines which are well adapted and show good levels of disease resistance will be tested further in the on-farm trials.

5. The project has developed a close working relationship with CIAT. International bean and adaptation nurseries and Central American yield nurseries for red and black beans were planted on the EAP farm. In addition, a nursery to measure damage by Apion godmani was initiated.

6. A small portion of the bean germplasm collection at EAP has been planted each growing season. In addition to renewing seed stocks, the germplasm bank nursery provides an opportunity for project personnel to evaluate the material for adaptation and disease resistance.

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use

1. Advanced lines have yielded well and have shown good levels of disease resistance under local conditions. These genotypes were sent to the bean breeding program at Colorado State University

and to USDA/ARS researchers at Michigan State University and Beltsville, Maryland to test for adaptation to US conditions. These genotypes also were tested in Honduras and the Dominican Republic.

2. Techniques for conducting a field crossing block were refined. The use of drip irrigation to maintain adequate moisture during the growing season increased the percentage of successful crosses. A field crossing block using drip irrigation appears to be a viable low-cost option for bean breeding programs in the tropics.

B. Available for Use Within One to Two Years

1. Erect black- and white-seeded lines resistant to BCMV, rust and anthracnose were tested under local conditions. The most promising lines will be sent to Honduras and the Dominican Republic for evaluation for adaptation and disease resistance.

2. A group of advanced lines derived from crosses between sources of rust and bacterial blight resistance will be available for evaluation in Honduras and the Dominican Republic.

3. Articles on the following topics will be prepared:

   a. The incidence of bean diseases in the Danli and Olancho departments of Honduras.

   b. Yield loss due to bean rust in Honduras.

   c. A review article on previous bean research in Honduras.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
Vélez-Martínez	M	UPR	Crop Protec.	M.S.		Partial
Honduras Citizens:						
del Rio	M	UPR	Crop Protec.	B.S.		Total
Others:						
None						

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
González	M	UPR	MSTAT Wkshp.	MSU	One week
Segarra	M	UPR	Prac. work. w/project	UPR	Two mos.
Dávila	M	UPR	Same	UPR	Two mos.

Honduras Citizens:

Cerna	M	EAP	Bean rsrch. techniques	UPR and DR	Three wks.
Mayr	F	EAP	Same	UPR and DR	Three wks.
Rodríguez	F	EAP	Spec. prob. wkg. w/proj.	EAP	One semester
Diaz	M	EAP	MSTAT Wkshp.	MSU	One week

Others
None

Project personnel also participated in a biological nitrogen fixation workshop at the EAP during July 1984. Ing. Diaz made a presentation at the workshop describing project activities in Honduras. The project also hired students from EAP on a part-time basis during peak periods of work. This arrangement provides them the opportunity to gain experience working with beans.

VIII. BASELINE DATA

Trials continued to be conducted on small farms in the Danli and Olancho departments. An additional year of data will provide a more reliable measure of bean production on small farms in Honduras. In addition to agronomic data, project personnel attempted to gather as much information as possible concerning the production and utilization of beans by the cooperating farmers.

IX. WOMEN IN DEVELOPMENT

A. Puerto Rico

1. Ms. Marisol Dávila, an undergraduate student in plant pathology, worked with the project for two months and received credit toward a summer practical requirement; Ms. Carmen Milagro Alicea, an undergraduate student in agronomy, is currently working with the project in a similar arrangement.

2. Ms. Mildred Zapata has applied for entrance to the University of Nebraska where she plans to initiate a Ph.D. degree program in plant pathology.

B. Honduras

1. Ms. Marjorie Mayr received three weeks of training in Puerto Rico and the Dominican Republic learning research techniques related to bean breeding and pathology

2. Ms. Laura Rodríguez spent a semester working with the project as part of a requirement for a special problem.

3. The project has provided some support to Ms. Ann Margoth Andrews, a Ph.D. candidate currently living at EAP. She has collected data concerning bean production on small farms in Honduras as part of the requirements for a special problem at the University of Florida.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO THE PROJECT

A survey of resources contributed by UPR and EAP is currently being conducted. Below is a list of some of the resources contributed by both institutions. Estimates of the value of these contributions will be reported in the near future.

A. University of Puerto Rico

1. Personnel

   Mr. Miguel Ruperto, technician, 20 percent, $1,200

2. Student training: Mr. Hirám Vélez-Martínez--Tuition waiver for graduate studies.

3. Facilities

Office space at the Mayagüez campus, UPR	100 square feet
Office space at the Isabela substation	100 square feet
Laboratory space at the Isabela substation	600 square feet
Crossing block at Isabela	800 square feet
Experimental fields at the Isabela substation	3 acres
Experimental fields at the Fortuna substation	2 acres
Experimental fields at the Limani substation	1/2 acre

4. Travel/transportation: Vehicles provided by the UPR agricultural experiment station for travel to the substations.

5. Indirect costs

   A major portion of the indirect costs for the project is supported by the University of Puerto Rico. During FY 84, the UPR contributed an estimated $33,965 toward indirect costs.

B. Honduras--Escuela Agrícola Panamericana

1. Facilities

Office space	264 square feet
Seed laboratory	423 square feet
Plant pathology laboratory	380 square feet
Seed cold room	169 square feet
Seed processing facilities	634 square feet
Experimental fields	4.8 acres

2. Travel/transportation: Vehicles provided by EAP for research-related travel.

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages: The project cooperated with a AID-supported biological nitrogen fixation (BNF) project at the University of Wisconsin. Project personnel assisted in the evaluation of high BNF bean germplasm for adaptation and disease resistance.

B. On-Going Linkages

1. Cooperation with the USDA-ARS bean research program at TARS has continued. Disease resistant bean germplasm developed from UPR/TARS collaboration forms an important base for the breeding program for Honduras.

2. Cooperation with the Ministry of Natural Resources (MNR) has been enhanced. The on-farm trials planted in June and September contained five red-seeded lines from CIAT which the MNR bean research personnel believe have the most potential for release as varieties. During the dry season, seed of bean germplasm of interest to the MNR was increased at EAP using irrigation.

3. Bean research in Honduras and Puerto Rico continues to benefit from collaboration with the CIAT bean research program. Several CIAT trials of interest to the project were planted in Honduras and Puerto Rico. CIAT personnel have traveled to Honduras and Puerto Rico to make observations on some of these trials.

4. Cooperative agreements with US universities and participation in Regional Project W-150 have permitted a high level of bean research to be maintained in Puerto Rico.

XII. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy

1. Puerto Rico

a. Crosses will be made to incorporate the "I" gene and recessive genes for resistance to BCMV into the small red, black and white seed types.

b. Backcrosses will be made in order to incorporate some of the multiple virus and common blight resistance found in interspecific (*Phaseolus vulgaris* x *P. coccineus*) crosses into a more adapted *P. vulgaris* genetic background.

c. The most promising genotypes of *P. coccineus* from the second and third cycle of recurrent selection will be identified. These will be used to form a population which will be considered for release.

d. The rust race found to be virulent to the B-190 source of resistance will be characterized by testing it on a set of differential bean varieties.

e. A group of populations derived from crosses between sources of rust and bacterial blight resistance will be advanced. The most promising advanced lines will be sent to Honduras for further testing.

f. A series of populations derived from crosses and backcrosses between genotypes with a small, red (Zamorano) seed type,

sources of multiple disease resistance and improved agronomic characteristics will be advanced.

g. Germplasm from other bean research programs will continue to be screened for adaptation and disease resistance. Trials from CIAT will include rust and bacterial blight nurseries. An adaptation nursery of promising lines for Central America also will be conducted.

h. Genotypes with the small, red (Zamorano) seed type will be crossed with sources of resistance to BGMV and web blight.

2. Honduras--Escuela Agrícola Panamericana

a. Conduct trials on small farms to:

(1) Obtain information on yield, adaptation and disease resistance of a group of promising bean lines.

(2) Measure the frequency and severity of bean diseases.

(3) Collect information on the production and utilization of beans by small farmers.

b. Evaluate the yield, adaptation and disease resistance and increase seed of bean genotypes stored in the EAP germplasm bank.

c. Evaluate CIAT bean germplasm for adaptation and disease resistance:

(1) Yield in adaptation nurseries.

(2) International bean rust nurseries.

(3) Bacterial blight nurseries.

(4) Web blight nurseries.

d. Assist in the preparation of a Resource Guide for Women in Agriculture in Honduras.

e. Make selections in F_2 and F_3 populations of red-seeded beans for plant and seed type and disease resistance.

f. Initiate a crossing block at EAP.

B. Training Objectives and Strategy

1. Puerto Rico

a. Ing. Hirám Vélez-Martínez will complete the requirements for an M.S. degree in crop protection at the Mayagüez campus, UPR.

b. Ms. Mildred Zapata-Serrano will initiate studies for a Ph.D. degree in plant pathology at the University of Nebraska.

2. Honduras

a. Ing. Luis del Rio will complete requirements for a B.S. degree in crop protection from the Mayagüez campus, UPR. Upon completion of a B.S., he will initiate an M.S. degree program in agronomy.

b. A Honduran student to be identified will begin an M.S. degree program at the Mayagüez campus, UPR.

c. A Honduran student to be identified will begin a B.S. degree program.

d. Ms. Denie Espinal will participate in a short course in bean research techniques at the Mayagüez campus, UPR.

e. A member of the Honduras research team will take part in a short course in bean technology at CIAT

C. Anticipated Personnel/Locational Changes

1. Puerto Rico

a. Dr. David Unander will dedicate 10 percent of his time working with problems related to the BCMV.

b. Ms. Mildred Zapata-Serrano plans to leave the project in August 1985 to begin graduate studies at the University of Nebraska.

2. A plant pathologist and a plant breeder at EAP plan to dedicate a portion of their time to project activities if funding proves to be adequate.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Beaver, J. S. 1984. The Use of Statistics in Bean Research. Presented at the Bean Research Workshop held at CESDA, San Cristobal, Dominican Republic, October 1984

Beaver, J. S., C. V. Paniagua, D. P. Coyne and G. F. Freytag. 1984. Yield Stability of Dry Bean Genotypes in the Dominican Republic. Submitted to Crop Science. (Available from J. Beaver, Department of Agronomy, University of Puerto Rico.)

Beaver, J. S., C. V. Paniagua, J. R. Steadman and R. Echávez-Badel. 1984. Reaction of Dry Bean Genotypes to Natural Infection of Foliar Diseases in the Dominican Republic. Submitted to Journal of Agriculture, University of Puerto Rico. (Available from J. Beaver, Department of Agronomy, University of Puerto Rico.)

INCAP • WASHINGTON STATE UNIVERSITY

Improved Biological Utilization and Availability of Dry Beans

I. PROJECT ROSTER

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

Principal Investigator:	Dr. B. G. Swanson, Department of Food Science and Human Nutrition, WSU
Co-Principal Investigators:	Dr. G. L. Hosfield, Department of Crop and Soil Sciences, Michigan State University (MSU)
	Dr. M. A. Uebersax, Department of Food Science and Human Nutrition, MSU
	Dr. P. A. Seib, Department of Grain Science, Kansas State University (KSU)
	Dr. R. C. Hoseney, Department of Grain Science, KSU
	Dr. D. R. Wood, Department of Agronomy, Colorado State University (CSU)
	Mr. L. Telek, US Department of Agriculture, Tropical Agriculture Research Station (USDA, TARS), University of Puerto Rico (UPR)
	Dr. G. Freytag, USDA, TARS, UPR
	Dr. J. López-Rosa, Department of Agronomy, UPR
Technicians:	Ms. M. Lauvier, Department of Food Science and Human Nutrition, MSU
	Mr. M. Ballarin, Department of Agronomy, CSU
	Mr. K. Cruz, USDA, TARS, UPR
	Ms. M. Zapata, USDA, TARS, UPR
Administrator:	Dr. D. L. Oldenstadt, Associate Director, Agricultural Research Center (ARC), WSU
Finance Officer:	Ms. A. Stutler, Business Office, ARC, WSU
Finance Officer:	Mr. Vince Hutnak, Controller, WSU
Accountants:	Ms. M. Bamberry, Grants Office, WSU
	Ms. B. Carlson, Grants Office, WSU
	Ms. L. Boyle, Grants Office, WSU
Institutional Representative:	Dr. L. L. Boyd, Director, ARC, WSU

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

Principal Investigator:	Dr. R. Bressani, Chief, Division of Agriculture and Food Science, INCAP

Co-Principal Investigators: Dr. E. Braham, Associate Director, Division de Ciencias Agrícolas y de Alimentos (DCAA), INCAP
Dr. L. Elías, DCAA, INCAP
Dr. R. Gómez-Brenes, DCAA, INCAP
Dr. M. Molina, DCAA, INCAP
Ing. C. Argueta, DCAA, INCAP
Mr. J. M. González, DCAA, INCAP
Ing. A. Garcia, DCAA, INCAP

C. USAID Project Officer: Mr. Harry Wing, Chief, Office of Rural Development, USAID/Guatemala

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives: The overall objective of this research project is to improve availability, utilization and nutritional quality of dry beans for human consumption in developing countries. This objective will be met by enhancing the availability of dry beans, improving or altering ways to prepare dry beans and by coordinating and standardizing genetic, nutrition, socio-economic and food science research efforts.

B. FY 84 Objectives: Specific objectives of this project were clarified in 1983-84 and are now delineated as follows:

1. Production

   a. Establish relationships among physical, chemical and technological factors and yield performance in common beans.

   b. Develop an understanding of the biochemical basis responsible for chemical, technological and nutritional properties of common beans.

   c. Establish nutritional quality standards for bean breeders.

   d. Develop a set of appropriate food technology and nutritional quality methodologies for screening programs.

2. Handling and Storage

   a. Study the environmental and genetic factors responsible for the mechanisms leading to seed color disappearance and the onset of hard-to-cook conditions.

   b. Develop appropriate storage equipment and conditions to reduce constraints to acceptability of beans by rural populations of Guatemala.

3. Utilization and Consumption

   a. Understand the significance and nutritional role of polyphenolic compounds, residual trypsin inhibitors and proteins resistant to digestibility.

b. Establish the need to increase sulfur amino acid content of dry beans to improve nutritional quality.

c. Establish physiological effects of eating dry beans.

d. Carry out surveys on preparation and consumption of dry beans within the family and on rural food preparations containing beans.

4. Processing and Food Product Development

a. Study the effects of processes and processing conditions on nutritional quality of beans.

b. Develop new forms of bean consumption directly or through new products.

III. CHANGE IN FY 84 OBJECTIVES

No substantial changes in objectives were made. Additional research on dry bean lectins was carried out, and design of collaborative studies of methods to assess procyanidins and cooking time were undertaken. Plans for a monograph on methods for screening bean nutritional and culinary quality and for a 1985 workshop on nutritional quality and acceptability of dry beans were presented to the Bean/Cowpea CRSP Technical Committee.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Communication among US co-investigators and between US and INCAP scientists, although improving, needs to be kept in mind.

B Invoicing and cost-sharing reports are more regular. Improvement in processing of subordinate agreements and reporting of expenditures by the Office of Grants and Contracts, Michigan State University, is necessary.

C Administration and reporting demand as much time as creative and productive research planning and progress.

V. PROGRESS TOWARD OBJECTIVES

Progress toward objectives was achieved in the four research areas: production, handling and storage, utilization and consumption and processing and food product development.

A. Production

1. Dominance is greater than additive variance for important culinary and nutritional traits of dry edible beans. Good agreement between combining ability effects in the F_2 and F_3 generations indicated that characteristics of parents transmitted to progeny persisted in advanced generations after hybridization. These results indicated that selection in early generations is possible for trait improvement (MSU).

Protein and procyanidin are inherited quantitatively. The mode of inheritance for culinary quality and nutritional traits can be improved through plant breeding (MSU).

Interaction between cultivar and locality was noted for total sulfur content of red, but not for black beans. A significant interaction between cultivar and locality for total sulfur amino acids was noted for black beans, but not for red beans. The environmental effect was more important than cultivar for both assays and for both red and black beans. Total sulfur may be an accurate indication of sulfur amino acids in dry beans.

Selection for high protein content in beans has been hindered by the strong influence of environment on seed protein parameters. Specific effects of soil water, shade and genotype on yield, seed weight, seed protein percent, protein content per seed and available methionine per milligram of protein were studied. Yield, seed weight and protein content per seed were different, and percent protein and available methionine were the same for three cultivars. Breeders are encouraged to look at protein content per seed, rather than percent protein, to minimize environmental effects on dry bean protein. Bean genotypes must be developed specifically for environmental niches defined by soil water. Shade treatments did not influence seed weight or available methionine (CSU).

Procyanidin and protein analysis of twenty lines of dry beans grown at three locations in Puerto Rico were completed. Beans with highly variable procyanidin and protein concentrations were selected. Agronomic characteristics and seed types look very promising and high protein beans may be available in the near future (UPR).

2. Chemo-taxonomic methods were used to assay tissue culture and differentiated state of dry beans in order to relate procyanidin and procyanidin precursors to the nutritional quality of dry bean cultivars. Procyanidin profiles will be used to examine heritability and stability of procyanidin phenotypes in tissue cultures and plant types (WSU).

   Interaction among phytate, proteins and minerals relate to the hard-to-cook phenomenon expressed by dry beans. Quantitative relationships among phytate, calcium and magnesium are predictive of dry bean cooking time (WSU).

3. A list of common cultivars of dry beans was published to encourage accumulation of research data for beans of known genetic background. A monograph containing laboratory methods for food scientists and plant breeders to screen dry bean quality is planned.

4. A method was developed for determination of soluble and bound procyanidins in dry beans (UPR).

B. Handling and Storage

1. Differential scanning calorimetry can be used to assess starch gelatinization and protein denaturation in dry beans during water absorption and cooking. Water is available for gelatinization and denaturation within fifteen minutes for beans placed in boiling water.

   Hard-to-cook beans are probably not due to ungelatinized starch or failure of raw bean protein to denature. Water migration does not limit cooking time of beans (KSU).

   A negative correlation was observed between seed weight and cooking time and between cooking time and percent water absorption. A positive correlation was observed between seed weight and water absorption (INCAP).

2. Beans soaked for five hours in 15 percent NaCl followed by sun-drying prior to storage contained significantly greater numbers of soft beans after 120 minutes of cooking than those stored with no treatment. The beans subject to salt soak to prevent hardening were acceptable to consumers (INCAP).

   A modified Morris-Mattson penetrometer with 25 positions was designed to fit into a standard 2000 ml beaker and is available for assay of dry bean cooking times (WSU).

   An instrument called the DUR-INCAP was developed to objectively assess the hardness of cooked beans by determining the force necessary for a blunt needle to penetrate through a cooked bean. Bean hardness is classified into soft, intermediate and hard gram-force regimes. White and black beans were softer after 140 minutes of cooking than red beans (INCAP).

   Cell separation is responsible for softening of beans during cooking. The grainy texture of hard-to-cook beans is due to clumps of cells which do not separate during cooking. Cell clumping is related to phytate-phytase, magnesium-phosphorous and calcium-pectin relationships. A subjective procedure to determine adequate cooking of beans is recommended (KSU).

   Scanning electron microscopy is an invaluable tool for studying the role of bean micro-structure during maturation, storage, water absorption and cooking. A literature review of dry bean micro-structure and water imbibition has been prepared and structural changes occurring during water imbibition were photographed and discussed (WSU and MSU).

C. Utilization and Consumption

1. Thermodynamic analysis of the temperature dependence of procyanidin dimer and trimer binding to bean glycoprotein G-1 was completed. Hydrophilic and hyrophobic interactions can occur between protein and procyanidin oligomers. Hydrophilic

interactions occur between procyanidin and native G-1, while hydrophobic interactions occur between procyanidin and denatured G-1. The strength of hydrophobic interactions increases with increases in temperature, enhancing reactions between procyanidins and proteins during thermal processing or cooking of dry beans. Removal of procyanidins from beans prior to cooking would enhance protein quality (WSU).

Protease inhibition by procyanidin increased with procyanidin molecular weight and concentration. Protease inhibition of procyanidin does not occur by irreversible binding to the enzyme active site. Procyanidin is not a specific protease inhibitor. Deleterious binding of procyanidin to protein can be overcome by sufficient additional protein or by removing procyanidin (WSU).

Feeding studies with bean broth demonstrate a significant negative correlation between procyanidin concentration and digestibility. White beans exhibited the best protein efficiency ratio (PER), weight gain and digestibility, with black beans intermediate and red beans relatively poor. Methionine supplementation reduced bean digestibility (INCAP).

Bean cooking time is positively influenced by the weight of the seed. Dry bean protein quality was related to bean color. Generally, dry beans with greater protein concentrations have lower protein quality than control dry beans. The reduction in protein quality may be due to an increase in total protein and a reduction in phaseolin (INCAP).

Alternative quantitative approaches for discriminating the protein quality of beans under different consumption patterns are available. The protein quality of fourteen bean cultivars was assessed in complementation with maize (INCAP).

Selected cultivars of dry beans have been distributed to US universities and INCAP to assess nutritional quality and provide physical, chemical, technological and nutritional reference values for use by researchers in breeding or utilization research programs.

Dry beans are a good source of protein and lysine. Dry beans are limiting in methionine and cystine, the sulfur-containing amino acids. Cultivars of dry beans vary widely in concentrations of trypsin inhibitors. No significant correlations were found between methionine, cystine and trypsin inhibitor concentration. The cooking time of dry bean cultivars also exhibited wide variation (INCAP).

Protein concentration ranged from 22.1 to 28.1 percent for beans distributed. In vitro digestibility ranged from 78.1 to 80.6 percent and tetrohymena-Relative Nutritional Value ranged from 0.30 to 0.62 for the twenty-one dry bean cultivars tested (WSU).

Methodology was developed that allowed sensitive measurement of phytohemagglutinin, the lectin of kidney beans. Hemagglutinating activity was observed in beans cooked at low temperatures for twelve hours (MSU).

Lectins from purified globular protein fraction of dry beans were inactivated at temperatures of 70°C or greater (WSU).

Black beans, Phaseolus vulgaris cv. Black Turtle Soup, were extracted and found to contain 0.75 percent dry weight procyanidin. Procyanidin intubations of 0.5 percent and 5.0 percent reduced rat growth rates 45 percent and 90 percent, respectively. Necropsy of 5.0 percent procyanidin intubated rats revealed abnormalities throughout the duodenum, jejunum and ileum. Procyanidins intubated with food were less toxic, but decreased growth rate, feed intake and feed efficiency of rats compared to controls. Procyanidins at 0.6 percent of diet in a 40 percent black bean diet did not decrease growth rate, feed intake or feed efficiency (WSU).

D. Processing and Food Product Development

1. Greater weight gain, PER and protein digestibilities were obtained with beans that had hulls removed before cooking. Bean seed coats have a significant influence on the nutritional value of beans (INCAP).

   Black beans with the seed coats removed were ground into flour, boiled as a 15 percent suspension in tap water, inoculated with a 1 percent suspension of lactic acid-producing micro-organisms and fermented for 16 hours at ambient temperature (ca. 25°C). Addition of sugar, salt and honey enhanced fermentation and consumer acceptance. The fermented product was acceptable and did not have a "beany" taste (INCAP).

2. Alternatives for utilization of beans would enhance demand and price and reduce post-harvest loss. Toasted black bean cotyledons were mixed 70:30 (bean:maize) and a gruel prepared and demonstrated to have acceptable quality (INCAP).

   Pigments extracted from black bean seed coats can be used to formulate a paste that resembles puree from cowpeas or chickpeas (INCAP).

   Extrusion is a good alternative for processing hard-to-cook beans to be used for animal feeding (INCAP).

   Preparation of precooked black bean flours with an extrusion or drum-drying process using mixtures of beans, soybeans and cowpeas reduced costs of production. Extrusion destroyed trypsin inhibitor activity; drum-drying did not (INCAP).

   Hard-to-cook, bitter black beans stored for two to three years can be soaked in a sodium salts solution, cooked, washed and dried in a double-drum drier and fed to animals. The product

retains a rancid/bitter taste, but the protein quality is similar to recently harvested beans. The bean product can be complemented with maize and is acceptable to experimental animals (INCAP).

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use

1. Culinary and nutritional traits of dry edible beans are inherited quantitatively and can be improved through plant breeding.

2. Total sulfur assays of beans may be an accurate indication of sulfur amino acid concentration.

3. Bean genotypes must be developed specifically for an environmental niche defined by soil water.

4. A list of common cultivars of dry beans has been published to encourage accumulation of research data for beans of known genetic background.

5. A method was developed for determination of soluble and bound procyanidins in dry beans.

6. Soaking beans in 15 percent NaCl for five hours and sun-drying them prior to storage inhibited the development of the hard-to-cook phenomena.

7. A modified Morris-Mattson penetrometer is available to assess cooking time of beans.

8. A review of the relationships of bean micro-structure to water inhibition is available.

9. Removal of procyanidins, removing the seed coats of colored beans, will enhance protein quality.

10. A method to assess hemagglutinin concentration and activity is available.

11. Extrusion of hard-to-cook black beans is a good alternative process to produce animal feed.

B. Available for Use Within One to Two Years

1. Environmental effects are more important than genetic effects when determining quality traits of dry beans.

2. Protein content in individual beans may be a better measure of protein, minimizing environmental effects.

3. Cultivars with increased protein concentration and protein quality will be developed.

4. Procyanidin concentration will be reduced in dry beans without affecting color.

5. Interactions among phytate, calcium, magnesium and pectin may enable prediction of cooking time.

6. Differential scanning calorimetry and scanning electron microscopy can be used to assess the role of water mobility and micro-structure in maturation and softening of cooked beans.

7. Lactic fermentations of bean flour suspensions provide an acceptable food product.

8. Development of extrusion and pigment extraction processes will permit greater use of hard-to-cook black beans.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
Wassimi	M	MSU	Crop & Soils	Ph.D.		Total
Coffey	M	MSU	FSHN*	Ph.D.		Partial
Artz	M	WSU	FSHN	Ph.D.	6/84	Total
Aw	F	WSU	FSHN	Ph.D.	6/83	Partial
Sendzicki	F	WSU	FSHN	M.S.	8/84	None
Birch	F	WSU	FSHN	M.S.	8/84	None
Caviness	M	WSU	FSHN	Ph.D.		None
Vindiola	F	KSU	Grain Sci.	M.S.		Total
Riggle	F	CSU	Agronomy	M.S.	6/84	None
Ballarin	M	CSU	Agronomy	M.S.	11/82	Partial
Froseth	M	WSU	FSHN	B.S.	6/84	None
Kim	F	KSU	Grain Sci.	Ph.D.		Total
Hoff	M	WSU	FSHN	Ph.D.		No info.
McClean	M	CSU	No info.	Ph.D.	6/82	None
Jensen	F	WSU	Nutrition	M.S.		Total
Hughes	M	WSU	Nutrition	M.S.		Total
Guatemalan Citizens:						
Martínez	F	INCAP	Food Science	M.S.		Partial
Arévalo	F	INCAP	Food Science	M.S.		Partial
Sosa Lemus	M	INCAP	Food Science	M.S.		Partial
Estrada	M	INCAP	Food Science	M.S.		Partial
Azucena	F	INCAP	Food Science	M.S.		None
de Garcia	F	INCAP	Food Science	M.S.		None
Rosado	M	INCAP	Food Science	M.S.		None
deLeón	M	INCAP	Food Science	M.S.		None
Rivera	M	INCAP	Food Science	M.S.		None
Masaya	F	INCAP	Food Science	M.S.		None

*FSHN--Food Science and Human Nutrition

Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
Guatemalan Citizens cont'd.:						
Castro	F	INCAP	Food Science	M.S.		None
Sialco	M	INCAP	Food Science	M.S.		Partial
Deleón	M	INCAP	Food Science	M.S.		Partial
Arriola	F	INCAP	Food Science	M.S.		Partial
Pereda	F	INCAP	Food Science	M.S.		Partial
Others:						
Nzuzzi	M	WSU	FSHN	M.S.		None
Joseph	F	WSU	Nutrition	Ph.D.		Total
Rasyid	M	WSU	FSHN	M.S.		None

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
Cruz	M	TARS-UPR	Procyanidin analysis	UPR	2 months
Zapata	F	TARS-UPR	Protein electrophoresis	UPR	2 months
Guatemalan Citizens:					
Argueta	M	INCAP	FS Training	MSU	6-8 weeks
Others:					
None					

Several US and foreign graduate students have completed theses based on research conducted with dry beans. Research efforts of Mr. Wassimi, Mr. Artz, Ms. Sendzicki, Ms. Aw, Ms. Rasyid and Ms. Riggle have been significant. Ing. Carlos Argueta (INCAP) is at Michigan State University and Ms. Renee Birch (WSU) is in Guatemala benefiting from experience and training. The annual meeting of investigators took place at INCAP, Guatemala. The team visited a bean experiment station in Jutiapa. A workshop on assessing acceptability and nutritional quality will be conducted at WSU and INCAP during FY 85.

VIII. BASELINE DATA

Baseline socio-economic data have been gathered by INCAP personnel and will be assimilated and published in the near future. Ms. Renee Birch is currently visiting Guatemala and plans to accumulate consumption and acceptability information, as well as nutritional quality perspectives for home-prepared beans and bean broth.

IX. WOMEN IN DEVELOPMENT

A. Women are encouraged to participate in research and training programs. Twenty-two percent of project personnel and 47 percent of project students are women.

B. Ms. Anne Ferguson of the Bean/Cowpea CRSP Management Office has initiated preparation of a resource guide with an overview of women's roles in agricultural production, processing and marketing in Guatemala.

C. Research progess is aimed at providing more acceptable, quicker-cooking and more nutritious beans for rural populations. Achievement of these goals will help alleviate hunger and poor health and provide a staple protein food that can be uniformly and conveniently prepared in the home.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. Washington State University

1. Personnel: Dr. Barry Swanson, professor, 35 percent, ca. $12,600
2. Students: Seven-eight students, ca. $20,000
3. Facilities: Two research laboratories, three offices , ca. 1,360 square feet
4. Materials/supplies: ca. $500
5. Travel: ca. $700
6. Indirect costs: ca. $15,210 and fringe benefits, ca. $222

B. Kansas State University

1. Personnel: Dr. Paul Seib, professor, plus one graduate student, 5 percent, ca. $5,000
2. Indirect costs: ca. $1,700

C. Michigan State University: Indirect costs: ca. $5,166

D. Colorado State University

1. Personnel: Dr. Don Wood, professor, 5 percent, ca. $3,200
2. Indirect costs: ca. $1,149

E. University of Puerto Rico: Indirect costs: ca. $10,164

F. INCAP

1. Personnel: ca. $14,654
2. Materials/supplies: ca. $1,995
3. Research facilities
4. Travel: ca. $530
5. Other direct: ca. $6,013
6. Indirect costs: ca. $7,553

G. Grand Total: $57,520

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages

1. United States

   a. Assistance was given in proposal writing for the East African cooperative project of the Bean/Cowpea CRSP and CIAT.

   b. Communication and project discussions were held with a representative of the USAID Mission, Zaire on bean research.

   c. A paper was presented at the Scanning Electron Microscopy, Inc. meetings.

2. Guatemala

   a. Communication and collaborative bean research were undertaken with Dr. S. Singh, IITA, Nigeria.

   b. Nutrition quality presentations were given at the Bean Improvement Cooperative meetings.

   c. Bean research cooperation was established with San Fernando, Honduras.

   d. Research collaboration was initiated with the Guatemalan National Institute for the Commercialization of Agricultural Products.

B. On-Going Linkages

1. United States

   a. Exchange of bean cultivars continues with CIAT.

   b. Research discussions were held with Western Regional Project W-150.

   c. Research discussions were held with the Bean Improvement Cooperative.

2. Guatemala

   a. Exchange of bean cultivars and socio-agronomic information with the Instituto de Ciencias y Technología Agrícola (ICTA).

   b. Exchange of bean cultivars occurred with CIAT.

   c. Dr. Fred Bliss of the Brazil/University of Wisconsin Bean/Cowpea CRSP project has assisted in protein analysis of beans.

XII. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy

1. Washington State University

   a. Survey consumption patterns, cooking, preparation and storage methods acceptable to rural populations of Guatemala.

   b. Investigate the nutritional quality of cooked beans and bean broth.

   c. Study the changes in micro-structure of beans during maturation, storage and water imbibition.

   d. Study phytate/calcium/magnesium relationships to the hard-to-cook phenomenon in dry beans.

   e. Study the nutritional significance of chemical interactions of proteins, carbohydrates, procyanidins and vitamins in dry beans.

   f. Evaluate tissue culture as a method to assess characteristic procyanidins in dry beans.

2. Michigan State University

   a. Expand studies on lectin development, procyanidin content, seed coat pigment and the hard-to-cook phenomenon in dry beans. Use controlled storage conditions under various gas environments, humidities and temperatures and relate the changes occurring to oxidation state.

   b. Continue studies on the determination of hemagglutinin concentrations of dry beans using an electrical gating technique. Research will include assessing hemagglutinin activity of different cultivars and the possibility of different forms of lectins through lectin purification.

   c. Initiate divergent selection for procyanidin content and measure correlated responses of cooking time and nutritional value. Obtain estimates of divergence and assymetry between high and low procyanidin populations.

3. Kansas State University

   a. Artifically age and determine if dry bean cells in hard-to-cook beans clump together.

   b. Prepare pure phytase and repeat Mattson experiment. Boil beans ten minutes, soak in phytase and determine if phytase-treated beans harden more than control beans.

c. Treat fresh cotyledons with pectin methylesterase in the presence and absence of Mg++ ions. Compare cooking time with control samples.

d. Obtain dry beans which harden at different rates and determine if pectin esterase and phytase activity vary in the beans. Verify that pectin is less soluble in aged beans.

e. Determine the effect of hot 80 percent ethanol on the cookability of beans and cotyledons. Vary the time of treatment and determine cooking time.

f. Soak fresh beans with varying concentrations of EDTA and/or sodium phytate. Age the beans and determine cookability and pectin solubility.

g. Microwave beans for different lengths of time; age and determine cookability.

4. University of Puerto Rico

a. Finish manuscripts on H_2SO_4-Butanol-Nylon and Vanillin methods for quantitative determination of procyanidins in dry beans.

b. Study chemical reactivity of procyanidins during cooking of dry beans.

c. Isolate and identify dry bean procyanidins by counter-current chromatography and therbium acetate isolation.

d. Continue to analyze advanced lines of dry beans. Conduct trials in preparation of release of superior quality, high protein, low procyanidin improved beans.

e. Apply protein and procyanidin analysis to progeny from the breeding program to select superior dry beans.

f. Develop electrophoresis of seed proteins and analyze the data by microcomputer, selecting superior parental lines and hybrids.

5. Colorado State University

Review CIAT international bean yield adaptation nursery advanced breeding lines and assay for principal physical and nutritional characteristics such as yield, protein quantity and quality, available methionine, water absorption, seed color degradation and cooking time.

6. INCAP

a. Carry out studies on adaptation and yield trials of white beans common to Guatemala.

b. Conduct biological assays to assess protein quality and digestibility of twenty-one bean cultivars from a collaborative study with MSU.

c. Assess chemical composition, amino acid content, protein quality and digestibility of bean broths. Evaluate physiological parameters associated with consumption of bean broth.

d. Use alternative quantitative approaches to discriminate protein quality of beans under different consumption patterns.

e. Evaluate the influence of procyanidins and fiber from the seed coat on the nutritional value of dry bean protein.

f. Chemically characterize extracted pigments of black beans.

g. Continue to develop alternative processes or products for utilization of fresh, stored and hard-to-cook beans.

h. Determine the impact of fermentation on flatulence, protein digestibility and quality of dry beans.

i. Continue acceptability and economic studies of extrusion processing of dry beans.

j. Develop a practical system to treat recently harvested beans with 15 percent saline prior to storage and evaluate the nutritional and cooking quality of stored beans.

B. Training Objectives and Strategy

1. Encourage graduate students to accept training assignments at INCAP.

2. Evaluate the five-week training program of Ms. Renee Birch at INCAP.

3. Encourage INCAP scientists to accept training assignments at US universities.

4. Collaborate on a methods publication and conduct a workshop on acceptability and nutritional quality of dry beans at WSU.

5. Encourage the exchange of US and INCAP scientists for training purposes.

6. Conduct a workshop on bean acceptability and nutritional quality at INCAP.

C. Anticipated Personnel/Locational Changes: Dr. George Hosfield, USDA/MSU, is planning research leave at WSU for January through December 1985.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Aguilera, J. M., E. B. Crisafulli, E. W. Lusas, M. A. Uebersax and M. E. Zabik. 1984. Air Classification and Extrusion of Navy Bean Fractions. Journal of Food Science 49:543-546.

Argueta, C., J. C. Rosado, M. R. Molina and R. Bressani. 1984. Evaluación de dos procesos para preparar harinas precocidas de frijol (P. vulgaris) parcialmente extendidas con soya y caupí. Paper presented at the Programa Cooperativo Centroaméricano para el Mejoramiento de Cultivos Alimenticios Meeting, Managua, Nicaragua, April 30-May 4, 1984.

Artz, W. E. 1984. Interaction of Procyanidin and Protein. Ph.D. Thesis, Washington State University.

Aw, T-L. and B. G. Swanson. In press. Influence of Tannin on Phaseolus vulgaris Protein Digestibility and Quality. Journal of Food Science.

Bliss, F. 1983. Breeding Beans for Greater Utilization. Paper presented at the symposium on dry bean nutrition and cooking quality, 1983 Biennial Meeting of the Bean Improvement Cooperative and National Bean Council, Minneapolis, MN, November 7-10, 1983.

Braham, J. E., R. Bressani and R. A. Gómez-Brenes. 1984. Effect of Bean Broth on the Nutritive Value and Digestibility of Beans. Submitted to Journal of the Science of Food and Agriculture (Available from J. E. Braham, INCAP, Guatemala).

_____. 1984. Efecto del caldo de frijol sobre el valor nutritivo y la digestibilidad de esta leguminosa. Paper presented at the Latin American Nutrition Society Meeting.

Bressani, R. 1984. Necesidades de investigación para elevar la calidad nutricional del frijol común (Phaseolus vulgaris). Paper presented at the Workshop on the Bean Program of Region VI, Guatemala (Jutiapa), sponsored by Instituto de Ciencias y Tecnología Agrícola, Guatemala.

_____. 1983. Nutritional Quality of Dry Beans. Paper presented at the 1983 Biennial Meeting of the Bean Improvement Cooperative and National Dry Bean Council, Minneapolis, MN, November 7-10, 1983.

Bressani, R., D. A. Navarrete and L. G. Elias. In press. The Nutritional Value of Diets Based on Starchy Foods and Common Beans. Qualitas Plantarum--Plant Foods for Human Nutrition.

Cruz, K., M. Zapata, L. Telek and G. F. Freytag. 1983. Determinación de taninos en semillas de una población seleccionada de Phaseolus coccineus. Paper presented at the 1983 Annual Meeting of the Sociedad Puertorriquena de Ciencias Agricolas, San Juan, PR.

Elias, L. G., R. Bressani and R. Sibrian. 1984. Efecto de la edad y del nivel de proteína sobre la digestibilidad aparente del frijol común (P. vulgaris). Paper presented at the Latin American Nutrition Society Meeting.

Elias, L. G., O. Martínez, R. Sibrian and R. Bressani. 1984. Development of an Accelerated Storage Method to Estimate and Predict the Common Bean Hardness Phenomena. Submitted to the Archivos Latinoaméricanos de Nutrición (Available from L. G. Elias, INCAP, Guatemala).

_____. 1984. Estudios sobre el mecanismo de endurecimiento del frijol. Aplicación de un metado de almacenamiento acelerado. Paper presented at the Programa Cooperativo Centroaméricano para el Mejoramiento de Cultivos Alimenticios Meeting, Managua, Nicaragua, April 30-May 4, 1984.

Elias, L. G., S. H. Orozco, O. Martínez, R. Sibrian and R. Bressani. 1984. Efecto genético y ambiental sobre algunas características nutricionales y technológicas del frijol común (P. vulgaris). Paper presented at the Latin American Nutrition Society Meeting.

Ghaderi, A., G. L. Hosfield, M. W. Adams and M. A. Uebersax. 1984. Variability in Culinary Quality, Component Interrelationships and Breeding Implications in Navy and Pinto Beans. Journal of the American Society of Horticultural Science 109:85-90.

Gómez-Brenes, R. A. and R. Bressani. 1984. Desarrollo, construcción y evaluación de un aparato para medir el tiempo de cocción del frijol y del maíz. Presented at the Programa Cooperativo Centroaméricano para el Mejoramiento de Cultivos Alimenticios Meeting, Managua, Nicaragua, April 30-May 4, 1984.

_____. In press. Desarrollo, construcción y evaluación de un aparato para medir la dureza y el tiempo de cocción de granos de frijol (P. vulgaris). Archivos Latinoaméricanos de Nutrición.

Hernández, R. F. and B. G. Swanson. 1984. Geosmin and 2-methylisoborneol in Processed Dry Beans. Journal of Food Science (Available from B. Swanson, Department of Food Science and Human Nutrition, Washington State University).

Hosfield, G. 1983. Processing and Cooking Qualities of Dry Beans. Paper presented at the symposium on dry bean nutrition and cooking quality, 1983 Biennial Meeting of the Bean Improvement Cooperative and National Bean Council, Minneapolis, MN, November 7-10, 1983.

Hosfield, G. L., A. Ghaderi and M. A. Uebersax. 1984. A Factor Analysis of Yield and Sensory and Physicochemical Data from Tests Used to Measure Culinary Quality in Dry Edible Beans. Canadian Journal of Plant Science 64:285-293.

Hosfield, G. L., M. A. Uebersax and T. G. Isleib. 1984. Seasonal and Genotypic Effects on Field and Physicochemical Seed Characteristics Related to Food Quality in Dry Edible Beans. Journal of the American Society of Horticultural Science 109:182-188.

Hughes, J. S., H. P. Rasmussen and B. G. Swanson. 1984. Food Microstructure: Review of Water Imbibition in Legumes. Paper presented at the Annual Scanning Electron Microscopy Meetings, Philadelphia, PA, April 1984.

INCAP. In press. Efecto de la radiación solar sobre algunas características físico-químicas del grano de frijol (P. vulgaris). Archivos Latinoaméricanos de Nutrición

Kelly, J. D., M. W. Adams, A. W. Saettler, G. L. Hosfield and A. Ghaderi. 1984. Registration of C-20 Navy Bean. Crop Science 24:822.

Lee, J. P., M. A. Uebersax, M. E. Zabik, G. L. Hosfield and E. W. Lucas. 1983. Physico-chemical Characteristics of Dry-Roasted Navy Bean Flavor Fractions. Journal of Food Science 48:1860-1962.

Molina, M., M. A. Baten and R. Bressani. 1984. Efecto del endurecimiento del frijol negro (P. vulgaris) y de algunos tratamientos para prevenirlo sobre características de las harinas precocidas elaborados. Paper presented at the Programa Cooperativo Centroaméricano para el Mejoramiento de Cultivos Alimenticios Meeting, Managua, Nicaragua, April 30-May 4, 1984.

Molina, M., G. de Masaya, M. A. Baten and R. Bressani. 1984. Efecto del almacenaje y tratamientos preventivos de endurecimiento sobre contenido de polifenoles y de diversas fracciones proteicas en dos variedades de frijol negro (P. vulgaris). Paper presented at the Programa Cooperativo Centroaméricano para el Mejoramiento de Cultivos Alimenticios Meeting, Managua, Nicaragua, April 30-May 4, 1984.

Riggle, R. L. 1984. Environmental Effects on Yield and Protein Parameters in Dry Beans (Phaseolus vulgaris). M.S. Thesis, Colorado State University.

Sendzicki, B. J. 1984. Influence of Procyanidins on the Gastro-Intestinal Tract of the Rat. M.S. Thesis, Washington State University.

Swanson, B. G. 1983. Production, Storage and Dry Bean Quality. Paper presented at the symposium on dry bean nutrition and cooking quality, 1983 Biennial Meeting of the Bean Improvement Cooperative and National Bean Council, Minneapolis, MN, November 7-10, 1983.

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KENYA • UNIVERSITY OF CALIFORNIA, DAVIS

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, Davis (UCD)

Principal Investigator:	Dr. Barbara D. Webster, Department of Agronomy and Range Science, UCD
Co-Principal Investigator:	Dr. J. Giles Waines, Department of Botany and Plant Sciences, UC Riverside (UCR)
Cooperators:	Dr. Ivan W. Buddenhagen, Department of Agronomy and Range Science, UCD
	Dr. Carl L. Tucker, Department of Agronomy and Range Science, UCD
Research Administrator:	Ms. Margaret Turano, Staff Research Associate, Department of Agronomy and Range Science, UCD
Research Manager:	Mr. David Barnhart, Staff Research Associate, Department of Botany and Plant Sciences, UCR
Research Associates:	Dr. Jorge Mosjidis, Department of Botany and Plant Sciences, UCR
	Dr. Paul Pechan, Department of Agronomy and Range Science, UCD
	Dr. David Lauter, Department of Agronomy and Range Science, UCD
Research Consultants:	Dr. Theodore C. Hsiao, Department of Land, Air and Water Resources, UCD
	Dr. Delbert W. Henderson, Department of Land, Air and Water Resources, UCD
	Dr. Donald N. Munns, Department of Land, Air and Water Resources, UCD
	Dr. J. Ian Stewart, World Hunger Through Response Farming, Davis, CA
Field Manager:	Ms. Cynthia Cory, Post-Graduate Researcher, Department of Agronomy and Range Science, UCD
Technician:	Mr. Christopher Corbett, Department of Botany and Plant Sciences, UCR
Budget Analyst:	Ms. Betty Bombard, Administrative Assistant, Department of Agronomy and Range Science, UCD
Institutional Representative:	Dr. Calvin Qualset, Associate Dean, College of Agriculture and Environmental Sciences, UCD

B. Kenya Counterpart Institution: University of Nairobi, Kenya (UNK)

Principal Investigator:	Dr. David N. Ngugi, Department of Crop Science, UNK
Research Scientists:	Dr. Chris Coulson, Department of Crop Science, UNK
	Dr. Francis Itulya, Department of Crop Science, UNK
Cooperators:	Dr. Shalomiah Keya, Department of Soil Science, UNK
	Dr. Erika Floor-Dries, National Horticultural Research Station, Thika
Research Consultants:	Dr. H. A. Van Rheenen, National Horticultural Research Station, Thika

C. USAID Project Officer: Dr. Curtis Nissly, USAID/Nairobi

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives: The overall (five-year) objective of the project is the development of high yielding, disease resistant cultivars of beans which are tolerant of the semiarid conditions in Kenya and suitable for cultivation by smallholder farm families.

1. Identify physiological and morphological markers to aid in efficient selection of germplasm for drought, heat and disease resistant bean cultivars which are environmentally and culturally adaptable in Kenya.

2. Develop common bean/tepary bean hybrids which incorporate the heat and drought tolerance of the tepary and maintain desirable seed and plant growth characteristics of common beans.

3. Establish collaborative relationships among Kenyan scientists and students at the UNK and at other Kenyan locations and US scientists and students at UCD and UCR.

B. FY 84 Objectives

1. United States

a. Evaluate bean/tepary hybrids for stand establishment, growth habits, time to maturity, seed yield and seed characteristics under low moisture regimes.

b. Participate in the worldwide drought adaptation study of beans in collaboration with CIAT.

c. Incorporate assessment of nitrogen fixation and nitrogen assimilation into measurements of growth parameters of beans and teparies.

d. Develop and field test interspecific hybrids of Kenyan bean cultivars and tepary beans.

e. Evaluate sensitivity to soil temperature resistance to Macrophomina, root development and pod and seed yield of selective hybrids.

f. Identify most sensitive growth stage of hybrids to low moisture regimes and high temperatures.

2. Kenya

a. Identify parameters of bean growth which contribute to yield reduction due to limited water and high temperature conditions.

b. Evaluate effects of varying amounts of water on flower abscission in beans.

c. Study growth and development of beans and teparies under natural rainfall conditions.

d. Investigate infestation of bean fly at experimental sites, assess damage and evaluate control methods.

e. Measure radiant energy conversion in bean cultivars.

f. Design and manufacture equipment for field measurements of soil temperature and/or automatic recording of environmental data at remote field sites.

g. Evaluate leaf temperature-air temperature differentials of beans growing at reduced water levels.

h. Identify growth characteristics associated with adaptation of beans in semiarid areas growing under differing agronomic conditions.

III. CHANGE IN FY 84 OBJECTIVES: None.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. After lengthy discussions with the Bean/Cowpea CRSP Management Office (MO), Technical Committee and Board of Directors (BOD), extensive changes in personnel participants at UNK were made. This necessitated a substantial reorganization and reassignment of responsibilities. Dr. David Ngugi, Chair of the Department of Crop Science and Dean of the Faculty of Agriculture at UNK, was approved by the BOD as the new Principal Investigator. Drs. Francis Itulya and Chris Coulson were to continue on the project and were to be joined by two new UCD-trained Kenyans: Dr. Benjamin Oruko and Dr. Julius Nyabundi. Dr. Shalomiah Keya, Chair of the Department of Soil Science at UNK and Director of Microbiological Resource Centers (MIRCEN), will join the project as a cooperator.

B. After discussions with the MO and with officials at UNK, a new more efficient system of fiscal accountability was put in place at UNK. This expedites the flow of funds between UCD and UNK.

C. The mutually beneficial working relationships between scientists at the National Horticultural Research Station at Thika working on the Grain Legume Project and project personnel at UNK (especially between Dr. Coulson and Dr. Floor-Dries) has ended with the cessation of activities of the Grain Legume Project and transfer of personnel.

D. Lack of available irrigation facilities at the major off-campus project research site (the Katumani Drylands Research Station at Machakos), coupled with the lack of rain in the experimental areas over three "rainy seasons," resulted in difficulties in maintaining experimental plots and hindered progress on the project. Irrigation at Katumani was scheduled to be completed in November 1984.

E. Greenhouse facilities at UNK are inadequate.

V. PROGRESS TOWARD OBJECTIVES

Progress has been attained in the following areas: Plant breeding, including hybrid development and selection; crop production, including agronomic practices, components of yield and nitrogen fixation; crop development, including identification of desirable morphological and physiological traits and patterns of growth.

Dr. Waines has made successful crosses between common beans and tepary beans utilizing Kenyan cultivars adapted to semiarid conditions and preferred by farmers in the region and wild and cultivated teparies collected from the southwestern US and northern Mexico. Seed increases and large-scale field trials were carried out in Kenya under extreme dry, hot conditions at Machanga and at Katumani and Kabete. Field trials in the US were carried out at UCD, UCR and UC field stations. Collections of drought and heat tolerant germplasm from worldwide resources were tested at UCD in cooperation with CIAT to identify desirable lines. New bean/tepary hybrids have been scored for disease resistance, nitrogen fixation, stand establishment (including initial root growth and canopy establishment), seed characteristics and yield. Some selections are now being grown at Kenyan field sites.

A. Current Year

1. The project participated with CIAT in the international bean drought adaptation nursery and in field testing at UCD with seventy-five genotypes of widely diverse backgrounds for drought tolerance.

2. Temperature tolerance and emergence of beans and teparies were investigated in a growth chamber study at UCR.

3. Studies of flower and pod set showed that flowers retained to maturity opened within six days of anthesis. All younger, more

apically positioned pods aborted. Seed and pod abortion were shown to be a consequence of post-fertilization processes.

4. Field studies compared yield potential of bean/tepary hybrids under normal and minimal irrigation at UCD.

5. Experimentation was undertaken at UCD on a line source sprinkler trial to assess the nitrogen fixation of beans and teparies under varying water conditions.

6. Large seed increase of bean/tepary hybrids was completed in the field at UCD.

7. Selection for drought tolerance and Macrophomina phaseolina resistance were carried out at UCR in the greenhouse and field.

8. The US and Kenyan PI and Co-PIs visited all projects during the year to assess progress and coordinate research.

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use

1. Large-scale field screening methods are available for identifying most drought tolerant genotypes of beans and teparies and bean x tepary hybrids.

2. Crossing and culture techniques were developed for establishing bean x tepary hybrids.

3. Kenyan and US bean cultivars with identifiable morphological markers related to drought and heat tolerance were identified.

4. Socio-economic data were collected from the Katumani area on smallholder farmers.

5. Data on drought and heat tolerance and growth characteristics of seventy-five bean genotypes were gathered to supplement the international screening trial being sponsored by CIAT.

6. Three common bean lines were developed at UCR that are resistant to bacterial blight and are currently being grown at CIAT.

7. Three tepary lines that show good yield potential at UCD under drought conditions are now available in Kenya and at CIAT for further experimentation.

8. Physiological data are available on dry matter partitioning, water-use efficiency, sink/source relationships and nitrogen fixation of teparies and common beans under drought conditions.

9. Techniques were developed for rapid estimation of pollen production and viability on an individual flower, whole plant or plant population basis.

B. Available for Use Within One to Two Years

1. Information derived from analysis of early growth and stand establishment of teparies, beans and the hybrids has enabled selection of particular genotypes with characteristics of rapid canopy establishment and deep rooting systems for more sophisticated drought tolerant studies.

2. With the development of embryo culture techniques for bean x tepary hybrids, several new media have been identified for hybrid establishment.

3. Exchange and increase of the most suitable germplasm between the US and Kenya have continued.

4. Best cultivars of beans from Kenya were field-tested at various hot, dry locations in the US and were utilized in bean x tepary crosses; selections for plant growth type, early maturity and seed characteristics have commenced.

5. Agronomic practices of smallholders in the experimental areas in Kenya were documented and field trials varying spacing, weeding, fertilizing and water delivery were carried out with most commonly grown bean cultivars in these areas. On-farm testing, utilizing the most feasible practices and bean cultivars, is now in the planning stage.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
Greaves	M	UCD	Intl Ag Dev	M.S.	3/84	Partial
Skully	M	UCD	Bot & PlSci	M.S.		Partial
Levy	F	UCR	Bot & PlSci	M.S.		None
Sage	F	UCD	Agronomy	Ph.D.		None
Kenya Citizens:						
Kamweti	F	UCD	Agronomy	M.S.		Total
Oruko	M	UCD	Land, Air & Water	Ph.D.		Partial
Nyabundi	M	UCD	Agronomy	Ph.D.		None
Ayiecho	M	UCD	Agronomy	Ph.D.		None
Omwega	M	UCR	Nematology	M.S.		Total
Others:						
Arrizon	M	UCD	Agronomy	M.S.		Partial
Sarath	M	UCD	Agronomy	Ph.D.	3/84	Partial
Dhugga	M	UCR	Bot & PlSci	Ph.D.		Partial

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
Cory	F	UCD	MSTAT	E. Lansing	1 week
Kenya Citizens:					
None					
Others:					
Mosjidis	M	UCR	MSTAT	E. Lansing	1 week
El Madina	M	UCR	Tep/bean res.	UCR	3 months
Stockinger	M	UCR	Tep/bean res.	UCR	2 months

With regard to degree training, at UCD, Mr. Michael Greaves completed an M.S. degree in international agricultural development. Mr. Enrique Arrizon is scheduled to complete the M.S. degree in agronomy in June 1985 and will return to Mexico. Both conducted research on drought stress of P. vulgaris and P. acutifolius. Dr. Gautam Sarath completed a Ph.D. on plant physiology with a focus on nitrogen efficiency and root nodule function in P. vulgaris. Ms. Tammy Sage will complete studies for the Ph.D. in plant physiology with research on carbon/nitrogen distribution in beans and its relationship to seed set and yield. Ms. Mary Kamweti from the UNK is pursuing studies for the M.S. in agronomy at UCD. Mr. Benjamin Oruko from the same university is completing studies for the Ph.D. on symbiotic relationships and nitrogen fixation. He will return to Kenya at the end of 1984 to join the project there. Mr. Julius Nyabundi from UNK is completing studies for a Ph.D. in physiology/ecology and will return to Kenya in 1985 to join the project. Mr. Patrick Ayiecho, also from the same university, is completing studies for a Ph.D. in genetics and will return to Kenya in 1985.

At UCR, Mr. Brian Skulley is working on an M.S. on temperature tolerances and seedling emergence in P. vulgaris and P. acutifolius. Mr. Kanwarpal Dhugga is pursuing a Ph.D. with research on nitrogen efficiency in P. vulgaris. Mr. Charles Omwega is also working toward a Ph.D. degree in nematology. Ms. Karen Levy is working on M.S. research on boron tolerance in beans.

In non-degree training, from UCD, Mr. Jorge Mosjidis (UCR) and Ms. Cynthia Cory attended the CRSP/MSTAT microcomputer workshop at MSU in August 1984. At UCR, Mr. Ebraham Dan El-Madina and Mr. Eric Stockinger received specialized training in association with work on teparies and beans. Mr. Stockinger is an undergraduate student.

VIII. BASELINE DATA

A. Three recent studies incorporating socio-economic background information from the Katumani region have been extrapolated to identify smallholder family roles and smallholder cropping patterns. This village-level data will be valuable in connection with the long-term goal of identifying bean cultivars most suitable for growth by smallholders in the semiarid areas and establishing the most feasible agronomic practices.

B. A study was initiated in Mexico by Dr. G. Waines to ascertain consumer preference of teparies. Results will later be extended to Kenya and related to the CRSP work there.

C. A literature search was carried out on the morphological and anatomical characteristics of beans and teparies in relation to drought tolerance and on changing patterns of rainfall in Africa.

D. Baseline data in the area of agro-meterology from studies in Kenya have been acquired.

IX. WOMEN IN DEVELOPMENT

The US PI and two of the major personnel on the project at UCD are women. Three females have received some graduate support from the project at UCD and UCR. One woman from Kenya is enrolled as a graduate student at UCD. The US PI serves as the UCD Women in Development representative.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States

1. Personnel: Departments of Agronomy (UCD) and Botany and Plant Science (UCR)

   Dr. Barbara D. Webster, 20 percent
   Dr. Giles Waines, 10 percent
   Mr. Carl Tucker, 5 percent
   Ms. Margaret Turano, 50 percent
   Ms. Cynthia Cory, 50 percent
   Ms. Betty Bombard, 5 percent
   Mr. D. Barnhart, 5 percent

2. Students: Partial support to three US students

3. Facilities

   Office space, five, totalling 500 square feet
   Headhouse and greenhouses, two, totalling 5,000 square feet, and related equipment
   Experimental fields, three, approximately 15 acres
   Growth chamber facilities, three

B. Kenya

1. Personnel

   All persons on the project are paid in full by the Kenya government.
   Secretarial assistance, 5 percent
   Technicians and a driver paid in part by government of Kenya.

2. Facilities

Greenhouse and seed storage facilities, laboratory space. Field sites (three) donated to the project by Kenyan government.

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages

1. United States

a. Germplasm was supplied to the Bean/Cowpea CRSP project at Washington State University/Tanzania, with an excellent meeting between UCD personnel and the project representative from WSU.

b. Germplasm was supplied to CIAT for field testing for drought and heat tolerance and was received from CIAT for field testing as part of the international drought tolerance trial. An excellent meeting was held between the CIAT representative and the UCD personnel at UCD.

c. Contact was established and a meeting was held between UCD project personnel and Purdue University scientists interested in the potential of teparies and bean/tepary hybrids for drought tolerance.

d. With the appointment of Dr. Ivan Buddenhagen to the agronomy faculty at UCD, a valuable new personnel linkage was established. Dr. Buddenhagen has had extensive experience with USAID and with international research centers.

2. Kenya: No information available.

B. On-Going Linkages

1. United States

a. The germplasm exchange between the project and CIAT continues.

b. Germplasm exchange for drought and heat studies continues with the Tanzania/Washington State University Bean/Cowpea CRSP project.

c. There are on-going consultations on physiological and breeding aspects of research with the Senegal/University of California, Riverside Bean/Cowpea CRSP project.

d. Consultation and germplasm exchange continues with the California Bean Board.

e. Information exchange takes place with the Bean Improvement Cooperative.

2. Kenya

   a. Cooperative field work was conducted at Thika and Kabete on drought resistance using a line source sprinkler system with the Grain Legume Project, Ministry of Agriculture.

   b. Unirrigated field plots for bean/tepary hybrid evaluation and testing were donated at the Katumani Dry Lands Research Station.

   c. The Kenya Ministry of Agriculture donated land at Machanga for drought and heat testing of beans and teparies.

   d. The Small Ruminants CRSP, Kabete, Kenya has helped with logistical and other problems.

XII. FY 85 PROPOSED PLAN OF WORK

A. Proposed Changes

The US research will continue primarily at UCR and at field stations in hot, dry areas of California.

1. Pursue the development of most promising bean/tepary hybrids and evaluate their yield and agronomic potential.

2. Continue investigations of pollen development, pollination, fertilization, pod and seed set in relation to drought and heat tolerance.

B. Proposed Plans for FY 85

1. United States

   a. Continue the assessment of patterns of growth, development and nitrogen fixation in field trials of beans and teparies showing drought/heat tolerance at UCD and UCR.

   b. Distribute selections of potential drought tolerant germplasm to the Katumani Dryland Station in Kenya where the FAO dryland legume breeder is assessing the material for disease resistance.

   c. Initiate study of seed characteristics in relation to cooking quality and cooking time in teparies, pursued especially in relation to a red and white speckled seed tepary that has been identified as most promising for drought and heat tolerance and as a hybrid parent.

   d. Continue studies of Macrophomina Phaseolina with teparies, beans and the hybrids in field situations, with collaborative research at the University of Sonoma, Mexico and UCR.

2. Kenya

a. Utilize the new irrigation system at the Katumani Dryland Research Station so that line source sprinkler screening experiments can be performed with various water regimes to enable efficient identification of drought tolerant genotypes.

b. Expand the breeding, physiology and nitrogen fixation components of the project as facets of research of the new investigators returning from UCD to Kenya (Messrs. Oruku, Nyabundi, Ayiecho).

c. Utilize new equipment for further physiological and morphological studies related to drought and heat tolerance.

d. Field test the new Kenyan common bean/tepary hybrids at Katumani, Kabete and other sites for drought tolerance.

C. Training Objectives

1. United States: Ms. Mary Kamweti (UCD) and Mr. Charles Omwega (UCR) will continue studies toward the M.S. degree. Dr. Paul Pechan will complete postdoctoral research in the area of reproductive biology of beans. Ms. Tammy Sage will complete studies for the Ph.D. in plant physiology.

2. Kenya: Mr. Benjamin Oruku, Mr. Julius Nyabundi and Mr. Patrick Ayiecho will return to UNK with Ph.D.'s from UCD and will join the Bean/Cowpea CRSP project there to expand the scope of research in breeding, nitrogen fixation and physiology/ecology.

XIII. LIST OF ARTICLES AND PRESENTATION ON PROJECT RESEARCH DURING FY 84

Cory, Cynthia L. and Barbara D. Webster. 1984. Assessment of Drought Tolerance in Cultivars of Phaseolus vulgaris and P. acutifolius. HortScience 19(3):68.

Lahsaiezadeh, M., I. P. Ting and J. G. Waines. 1984. Drought Resistance in Chinese Spring Wheat/Imperial Rye Addition and Substitution Lines. Proceedings of the Sixth International Wheat Genetics Symposium, Kyoto, Japan, November 29-December 4, 1984.

Pechan, Paul M. and Barbara D. Webster. In press. Determination of Pollen Number of Phaseolus vulgaris L. Using an Electrical Particle-Counting Device. Journal of American Society for Horticultural Science.

_____. 1984. Flower and Pod Set of Phaseolus vulgaris L. Under Controlled Environment Conditions. Submitted to the Journal of American Society for Horticultural Science. (Available from B. Webster, Department of Agronomy and Range Science, University of California, Davis.)

Sage, Tammy Lynn and Barbara D. Webster. 1984. ^{14}C-Photoassimilate Partitioning in Morphological Reproductive Units of Phaseolus vulgaris L. Plant Physiology 75(S):161.

_____. 1984. Transport Pathway of Sucrose into Embryos of Phaseolus vulgaris L. American Journal of Botany 71:126.

Sarath, Gautam. 1984. Aspects of Nodule Development and Hormone Interaction in Phaseolus vulgaris L. Ph.D. Dissertation, University of California, Davis.

Sarath, Gautam and Barbara D. Webster. In press. Effects of Growth Regulators on Root Nodule Function in Phaseolus vulgaris L. I. Plant Growth, Nitrogen and Dry Matter Partitioning. Journal of Plant Growth Regulation.

_____. 1984. The Effects of Growth Regulators on Assimilate Partitioning in Nodulated Plants of Phaseolus vulgaris L. Plant Physiology 75(S):154.

Thomas, C. V. and J. G. Waines. 1984. Fertile Backcross and Allotetraploid Plants from Crosses between Tepary Beans and Common Beans. Journal of Heredity 75:93-98.

Turano, Margaret Jorgensen and Barbara D. Webster. 1984. Anatomical and Histochemical Characteristics of the Stigma of Cicer arietinum L. HortScience 19(3):67.

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Zimmermann, M. J. O., A. A. Rosielle, J. G. Waines and K. W. Foster. In press. A Heritability and Correlation Study of Grain Yield, Yield Components and Harvest Index of Common Bean in Sole Crop and Intercrop. Field Crop Research.

Zimmermann, M. J. O., A. A. Rosielle, K. W. Foster and J. G. Waines. 1984. Gene Action for Grain Yield and Harvest Index of Common Bean Grown in Sole Crop and in Intercrop with Maize. Field Crop Research 9:109-118.

MALAWI • MICHIGAN STATE UNIVERSITY

Genetic, Agronomic and Socio-Cultural Analysis of Diversity Among Bean Landraces 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. Patricia Barnes-McConnell, Bean/Cowpea CRSP Management Office, MSU
Research Assistant:	Mr. Greg Martin, Department of Crop and Soil Sciences, MSU
Contracts and Grants Officer:	Mr. Gerald Jacobs, Contracts and Grants Office, MSU
Board of Directors Delegate:	Dr. Dale Harpstead, Chair, Department of Crop and Soil Sciences, MSU
Institutional Representative:	Dr. James Anderson, Dean, College of Agriculture and Natural Resources, 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 Social Science Field Research Supervisor:	Dr. Ellen Bortei-Doku, Department of Crop and Soil Sciences, MSU

C. USAID Project Officer: Dr. William Judy, Agricultural Officer, USAID Malawi

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives

1. Discover those genetic, agronomic and socio-cultural forces that account for the persistent pattern of bean landrace diversity in Malawi.

2. Distill from the findings and experiences in Malawi a set of principles concerning the acceptance criteria that must be met in attempts to replace traditional landraces by improved cultivars or populations.

3. Bring out the integral role of Malawian farm women in cultivar (landrace) evaluation, production, utilization and acceptance.

4. Provide educational and training opportunities for Malawian and US scientists and students.

B. FY 84 Objectives

1. Complete initial experiments on estimation of rate of outcrossing in beans in Malawi.

2. Complete initial descriptions of patterns of genetic diversity in and among bean landraces in northern Malawi.

3. Commence long-term performance and stability trials of landraces, mixtures and pure-line components.

4. Place the socio-cultural teams composed of Malawian women in farm villages and homes in northern Malawi.

5. Summarize data from the initial 1982 pilot-study teams of socio-cultural observers.

III. CHANGE IN FY 84 OBJECTIVES

Because of a delay in the completion of degree requirements, the researcher scheduled to go to Malawi in June 1984 to supervise the socio-cultural investigations in northern Malawi was unable to leave until October 1984. Consequently, objective 4 above was not achieved.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. See III above.

B. Beans from Malawi planted at MSU in June 1983, for use in graduate student training and for germplasm evaluation, did not flower under the Michigan photoperiod and no seed was obtained.

V. PROGRESS TOWARD OBJECTIVES

A. Genetic Diversity

1. The main thrust of the project up to this time has been to quantify the genetic structure of Malawian bean landraces, and to explain the origin and maintenance of genetic diversity on genetic, agronomic and socio-cultural grounds. Excellent progress has been made in quantifying the genetic structure of landraces, and a strong hypothesis has been developed suggesting the genetic origin and maintenance of the diversity.

The chief work on these questions was performed by Mr. Greg Martin, Masters candidate in residence in Bunda College for one year, 1982-83. His work culminated in a thesis entitled "Genetic Diversity of Bean Landraces in Northern Malawi". Fifteen landraces, three from each of five areas of northern Malawi, were selected for study. Seed increase plantings of each landrace were made at Bunda College. At maturity,

self-seed (insecticide was used to prevent natural crossing) was taken from the first twenty-five plants in each landrace plot. The resulting 375 lines were then planted at Bunda in three replications (10 seeds/plot) for data collection. Data were taken on five phenological, eleven morphological, five agronomic and five qualitative characteristics. Analysis of variance for the twenty-one metrical traits showed significance among lines for all of them, and they were subsequently included in the multivariate principal components distance analysis (PCDA) by means of which variability was assessed between areas, between farms within areas and among lines within farms.

In addition to the great diversity shown for qualitative seed coat colors and patterns, some impression of metrical trait diversity can be gained from an examination of the means and range for a few of the twenty-one metrical characters, as given below:

Character	Mean	Range
Days to first flower	51	44-65
Duration of flowering	19	5-32
Days to physiological maturity	97	84-118
Nodes on main stem	16	5-31
Leaflet area (cm)	47	10-81
Single seed weight (centigms)	43	12-68
Seeds/pod	4.5	2-7
Pods/plant	32	2.5-100
Seed yield/plant (gms)	59	2.5-163
# seeds/plant	147	8.6-480

In view of the extremely low yields or numbers of seeds/plant of some lines, it is surprising that such genotypes are found in landraces. It is expected that such types would be lost quickly in mixtures under field conditions. Most likely they are short-lived transients.

Based upon the PCDA, each of the five areas could be clearly separated from the others. But for principal axes I and II, areas 2 and 3 (Misuku Hills and Livingstonia) are quite close. If the mean values of the landraces found in areas 2 and 3 are compared for certain traits, the basis of the close relationship is noted:

Character	Area 2	Area 3
Days to first flower	50.15	50.61
Days to end of flowering	67.20	66.79
Duration of flowering	17.06	16.18
Leaflet are (cm)	44.49	44.31
Single seed weight (centigms)	40.00	39.00
Seeds/pod	4.59	4.66
Pods/plant	32.89	31.33
Seeds/plant	154.12	154.43

In seed types, however, areas 2 and 3 are not at all similar. So it is not accepted that the landraces of areas 2 and 3 are the same or necessarily highly related, except in regard to certain traits. One possible explanation is that, at one time, the landraces in Misuku and Livingstonia traced to a common gene pool. On account of geographic separation and being grown by farmers with particular seed color preferences, however, the landraces in Misuku and Livingstonia have diverged from each other in that respect even while retaining similar genes for those traits by which they appear related.

Great diversity in landraces is shown by PCDA for lines within races. Minimal distances between the two most similar lines of each landrace, indicating very close genetic relationship if not genetic identity, ranged in the fifteen landraces from .0749 to .2411. Maximum pair distances ranged from 1.1184 to 1.3215 for the fifteen landraces. These figures suggest that some landraces are comprised of several closely related, if not identical siblings. These are interspersed with highly unrelated genotypes, as though arising from simple mechanical mixtures of two or more distinct homogeneous components.

Landraces differ in degree from this model, but they also differ in a second and more significant sense. That is in the extent to which natural crossing has occurred between either closely related or unrelated components within a landrace. In either case, crossing followed by normal selfing will produce a swarm of genetic recombinants that add significantly to the variability within a landrace. The variability is greatest when unrelated components are involved in the natural cross.

Thus, individual landraces range from relatively simple mechanical mixtures of unrelated types, to biologically dynamic populations of great heterogeneity involving basic parental components, and their intercross hybrids and recombinant derivatives.

2. With respect to the origin and maintenance of genetic variability in landraces in Malawi, the following scenario is postulated:

   a. Physical mixing of two or more contrasting seed and/or plant types and their propagation in farmers' fields.

   b. Natural crossing between contrasting components.

   c. Hybrid seeds retained in the mixture by the farmer.

   d. The hybrid(s) self-pollinates, genetic elements recombine, and new recombinants are formed.

   e. The new recombinants--some, many or all--are retained, prove to be productive enough to survive successfully and continue to leave progeny in the "landrace".

B. Performance of Pure Lines and Mixtures

Trial I: Field trials were conducted at five sites during the 1983-84 growing season: Bunda College at 1118 meters above sea level, Dedza at 1650 meters, Dowa at 1200 meters, Misuku Hills at 1400 meters and Thyolo at 840 meters. There were thirty entries made up of sixteen pure lines, nine artificial mixtures, one natural mixture, one F_2 bulked population, two control varieties and one hybrid maize variety. All bean entries were planted on ridges in association with maize. Density of maize was equivalent to 36,000 plants/ha and beans 48,000 plants/ha. Mean bean yields per site ranged from 306 kg/ha at Thyolo to 757 kg/ha at Dedza.

No single entry yielded consistently highest at all locations. The natural mixture ranked fifth across all sites, and the F_2 ranked third. The highest rank was achieved by a two-line mixture. Relative yield of mixtures, calculated as the ratio of yield of all mixtures to the weighted yield of the pure-line components, ranged from 0.79 at Thyolo to 1.30 at Dowa. The site average relative yield was 1.07, indicating mixtures yielded 7 percent higher than pure lines. Individual mixtures ranged in relative yield from 0.88 to 1.30. The data are from a single season and thus should be taken only as preliminary.

2. Trial II: A second series of trials were conducted at the same sites, except that all bean entries were grown without maize. These trials also were done on thirty entries but not the same as trial I because of shortage of seed. With yields of entries averaged over locations, the relative or unit contribution to yield was in the following order:

Entries	Unit Contribution	Yield relative to 18 pure lines
2 control varieties	2.7	0.84
18 pure lines	3.2	1.00
8 artificial mixtures	3.5	1.09
1 natural mixture	4.8	1.50
1 F_2 bulk population	3.0	0.94

Thus, the artificial mixtures, grown in plots without maize, displayed a relative yield (1.09) similar to that of mixtures grown with maize (1.07). The natural mixture, grown without maize, was 50 percent higher yielding in these trials as compared with the pure-lines. Only in the Misuku Hills did the natural mixture, originally from Dowa, yield less than the average of the pure-lines.

Individual mixtures, composed of from two to thirteen components, displayed relative yields ranging from .55 to as high as 1.47, depending upon the location. The artificial mixtures were more successful in Dowa and least successful, as compared to their weighted pure-line component yields, in the

Misuku Hills, where natural mixtures abound. There appear to be strong mixture by site-specific effects with respect to yield.

Preliminary data regarding the relative contributions of pure-line components in mixtures indicate major shifts in proportions for the components at particular sites. For example, for a simple 50/50 mixture of two components, after the first season the proportions at Dedza were in the ratio .49 to .51, whereas in the Misuku Hills the ratio had dropped to .33 to .67. Similar shifts have shown up for more complex mixtures. These changes also imply strong genotype by site specificity.

C. Socio-Cultural Component

1. Phase I (1982): This consisted of a team of Bunda College female students trained and field tested in methodology by a US social science team in collaboration with the Malawian team. Technical Report No. 1 presents this work.

2. Phase II (1983): A six-week pilot study by the trained team was carried out in the northern region of Malawi. Technical Report No. 2 presents the findings of this work.

3. Phase III (1984): Four young village women (two teams of two), having completed an appropriate level of public education and fluent in English and the local languages, were identified by the Malawian project personnel. These new village teams were trained as enumerators by the previously trained and now experienced Bunda College team. The village teams established residence in the assigned areas where beans are grown and carried out the research over a four-six month period, sampling forty families. Families were identified by the extension agents as known growers of beans. The purpose of this phase was to prepare the new teams for Phase IV and to identify the pool of families from which a smaller number could be chosen for the year-long study. Technical Report No. 3 gives the results of this work.

4. Phase IV (1984-85): From the forty families, five were chosen per village research team to be studied over a year's time. Criteria for selection were their willingness to participate and the ability of the team to identify a reasonably close residence (maximum of two-hour walk one way). Two additional teams to cover other parts of the region were identified and are being trained and outfitted as the others (clothes, shoes, research materials). A field supervisor finally completed the requirements for the Ph.D. degree in rural sociology and, in October, moved to the area. A standard visitation schedule for each set of five families was developed for the teams. As a result of these procedures, a total of twenty families, five in each of four ecologically different bean growing areas in northern Malawi, are being intensively observed for a year.

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use: An M.S. thesis entitled "Genetic Diversity of Bean Landraces in Northern Malawi" was completed by Mr. Greg Martin.

B. Available for Use Within One to Two Years: Two performance and stability trials at four locations each were conducted for one season. The entries included both pure-lines and mixtures and were grown with and without maize. The one-season data, while suggestive, are not sufficient for drawing long-term conclusions of significance to agronomists, extension agents, policy-makers or farmers. Within two additional years (hopefully three to four cropping seasons), a substantial enough database should exist to permit conclusions to be reached.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
Martin	M	MSU	Crop & Soil	M.S.	8/84	Partial
Morss	F	MSU	Crop & Soil	Ph.D.		None
Malawi Citizens:						
Bokosi	M	MSU	Crop & Soil	M.S.		None
Mloza-Banda	M	MSU	Crop & Soil	M.S.		Partial
Mkandawire	M	MSU	Crop & Soil	Ph.D.		Partial
Others:						
Abani	M	MSU	Computer Sci	Ph.D.		Partial
Kamali	M	MSU	Sociology	Ph.D.		Partial

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
Morss	F	MSU	MSTAT Wkshp.	MSU	One week
Malawi Citizens:					
4 female enumerators			Observation techniques	On-site	Two weeks

Mr. Alex Mkandawire, from Malawi, is a Ph.D. candidate in crop physiology and management at MSU. He is evaluating lines from the Malawi gene pool for tolerance or resistance to drought stress, particularly as created by growing beans in competition with maize.

Mr. James Bokosi, from Malawi, is a Masters candidate who is attempting to identify races of anthracnose in Malawi to establish the relative frequencies of resistance and susceptibility of Malawi lines to Malawi races of anthracnose and to Colombian and Mexican/Guatemalan races of anthracnose.

Mr. Henry Mloza-Banda, also from Malawi, is a Masters candidate in rhizobiology who is attempting to determine the nitrogen-fixing capability of a sample of Malawian lines inoculated with a Malawian rhizobial isolate under combinations of applied nitrogen and phosphorous.

Ms. Susan Morss, from the US, is a Ph.D. student who is in the process of estimating genetic diversity in and among landraces by the use of electrophoretic polymorphisms. She is also interested in methods for the creation of superior mixtures or landraces.

VIII. BASELINE DATA

A. Data on phenological, morphological and agronomic characteristics of 375 pure-lines (components of landraces) were obtained in the course of the research reported in the M.S. thesis of Mr. Greg Martin.

B. Data were obtained on phenology and yield of thirty entries (pure-lines and mixtures) grown at four locations in 1983-84, with and without maize.

C. Socio-cultural data from the pilot study were gathered.

D. Data from A and B above are directly relevant to project objectives. Data in C above are from an exploratory pilot study of socio-cultural characteristics of bean-growing farm families and are only partly related to project objectives II.A.1 but are directly related to project objectives II.A.3.

IX. WOMEN IN DEVELOPMENT

A. <u>United States</u>

1. Dr. Patricia Barnes-McConnell, social scientist, is Co-PI.

2. Ms. Susan Morss, US citizen raised in Zimbabwe, is a research student with the project.

B. <u>Malawi</u>

1. Dr. Ellen Bortei-Doku, a recent graduate in rural sociology, MSU, and a citizen of Ghana, has joined the project as supervisor and coordinator of the socio-cultural research teams in northern Malawi.

2. The socio-cultural research teams consist of Malawian young women, former students of Bunda College, trained by Drs. Barnes-McConnell and Edje for this task. The presence and

activities of the socio-cultural research team in northern Malawi have had a small but noticeable impact on the communities where they work.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO THE PROJECT

A. United States

1. Personnel

Dr. M. W. Adams, professor, crop and soil sciences, 10 percent, $5,200
Dr. P. W. Barnes-McConnell, Director, Bean/Cowpea CRSP MO, 10 percent

2. Student training: Ms. Susan Morss, graduate assistant paid by Department of Crop and Soil Sciences, $8,000

3. Facilities: Lab and greenhouse space, 1800 square feet

4. Materials and supplies: $2,300

5. Travel/transportation: $100

6. Indirect costs: $8,442

B. Malawi

1. Personnel

Dr. Todo Edje, professor, Bunda College, 20 percent, $1,600

Student/clerical workers, $5,400

2. Student training: $3,000

3. Facilities: 6,000 square feet of enclosed space; six to ten hectares of field space

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages: None.

B. On-Going Linkages

1. United States: Seed from the Malawian collections will be provided to Mr. Paul Gepts of the University of Wisconsin to supplement work on protein polymorphism in relation to postulated origins of common beans.

2. Malawi: Bunda College enjoys significant cooperation from the Malawi Ministry of Agriculture and Ministry of Finance in this project. The project also receives considerable advice and support from USAID/Lilongwe.

XII. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy

1. United States

   a. Write and submit for publication two papers from Mr. Greg Martin's thesis. Complete one manuscript on earlier data as an introductory paper.

   b. Commence electrophoretic typing of landrace components from the Martin collection. Based on preliminary work done by Ms. S. Morss in 1983-84, typing for several electrophoretic variants will be carried out on the 375 pure-line components established by Mr. Martin. These data will be used to characterize patterns of diversity within and between landraces, and a comparison will be made with the picture that emerged from the principal components analysis done by Mr. Martin on the same lines and races.

   c. Continue analysis and summarization of socio-cultural data from the 1982 pilot study and of the extension of the pilot study in 1983 on selected farm families of northern Malawi.

      Complete establishment of the two-person teams of interviews/observers in three areas of northern Malawi (Mzuzu, Rumphi and Misuku Hills), with each team having responsibility for five farm families. A supervisor, Dr. Ellen Bortei-Doku, has recently arrived in Malawi and will reside in Mzuzu. Questionnaires and observational protocols derived from the pilot study and subsequent contacts have been prepared for team use, and a visitation schedule by the supervisor was agreed upon. The objective is to observe farm families for a one-year period, noting all activities connected with beans, from planting to harvesting, storage, selling and consuming. Particular attention will be given to activities that might be relevant to the diversity question, to factors that affect the acceptance of one type of bean or another and to the role of women in the process.

2. Malawi

   a. The performance and stability trials established in FY 84 will be continued with no change since these experiments require several seasons to produce meaningful data. They are, in fact, fundamental to the analysis of adaptation and genetic diversity from the agronomic sense.

   b. In addition, parallel to the stability trial, a new trial, with similar entries of pure-lines and mixtures, will be established in FY 85 for the purpose of monitoring shifts in frequency of particular genotypes in mixtures and/or races over locations and times. In this trial, the seed

and types from each entry will be enumerated and replanted without attempt to reconstitute or restore the original frequencies of types in the mixture or race. This is in order to permit given genotypes to rise or fall in frequency based completely on their natural selective advantage or disadvantage under the conditions of the trial-simulated farm conditions. The selective values will be determined, and the fluctuation in selective values from location to location and for seasons will be evaluated.

If selective values of particular genotypes tend to fluctuate significantly over time or location, this may be a major reason for the maintenance of genetic diversity patterns in landraces. It would also have strong implications for the question of development of successful and acceptable cultivars or landraces to replace those now being grown.

c. The socio-cultural research described in XII.A.1.c above is largely centered in Malawi and will not be further noted here.

B. Training Objectives and Strategy

1. United States

a. Ms. Susan Morss, doctoral candidate in plant breeding and genetics, will do the electrophoretic research alluded to above under XII.A.1.b. In addition, a study of strategies for development of superior landraces is being discussed which may be inaugurated later this year or possibly next, possibly requiring Ms. Morss to spend time in Malawi and/or South America.

b. The three Malawian students, Messrs. Bokosi, Mloza-Banda and Mkandawire, will continue their research studies and coursework as planned: Mr. Bokosi on identifying races of anthracnose from diseased samples brought in from Malawi and in evaluating the reaction of Malawian germplasm to those races; Mr. Mloza-Banda on evaluating Malawian lines to both a Malawian rhizobium isolate and to efficient strains of rhizobia from the US or South America; and Mr. Mkandawire on evaluating Malawian lines (pure components of landraces) for tolerance to drought induced by growing with maize under moisture stress conditions.

2. Malawi

a. An assistantship as a research associate will be offered to a candidate in the Home Economics/Nutrition Department of Bunda College. The candidate will study for an M.S. degree in the US in the area of home economics/nutrition.

b. Two additional Malawians, one male and one female will be employed full-time as technicians on the project while studying part-time for their M.S. degrees at the University of Malawi.

C. Anticipated Personnel/Locational Changes: None.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Bortei-Doku, Ellen, P. W. Barnes-McConnell and O. T. Edje. 1984. Malawi: Focus on a Bean Culture. Manuscript prepared for the Bean/Cowpea CRSP External Review Panel's review of the Malawi project. East Lansing, MI: Michigan State University, Bean/Cowpea CRSP Management Office.

Kamiar, Mohammad and P. W. Barnes-McConnell. 1984. Preliminary Findings from Phase 3 of the Social Science Pilot Study in Northern Malawi--Bean/Cowpea CRSP Malawi Project. Technical Report No. 3, The Bean/Cowpea CRSP Malawi Project. East Lansing, MI: Michigan State University, Bean/Cowpea CRSP Management Office.

Martin, Greg. 1984. Genetic Diversity of Bean Landraces in Northern Malawi. M.S. Thesis, Michigan State University.

During the year, progress reports were made to Bunda College with USAID Mission officers and Ministry of Agriculture representatives invited to attend.

MEXICO • MICHIGAN STATE UNIVERSITY

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 (UM)
Contracts and Grants Officer:	Mr. Gerald Jacobs, Contracts and Grants Office, MSU
Board of Directors Delegate:	Dr. Dale Harpstead, Chair, Department of Crop and Soil Sciences, MSU
Institutional Representative:	Dr. James Anderson, Dean, College of Agriculture and Natural Resources, MSU

B. Host Country Institution: Instituto Nacional de Investigaciones Agrícolas (INIA)

Principal Investigator:	Dr. Rogelio Lépiz, National Coordinator, Bean Program, INIA
Co-Principal Investigators:	Ing. Abelardo Nuñez, INIA Dr. Ronald Fererra, INIA

C. USAID Project Officer: Mr. Sam Taylor, US Embassy, Mexico City

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives

1. 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.

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

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

4. Identify, through screening and selection in populations of Mexican seed types and from other sources, bean genotypes having:

a. High and low levels of tolerance to drought.

b. High and low levels of biological nitrogen fixation (BNF).

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

6. Assess the importance of certain plant growth and phenological characteristics on parameters of N_2 fixation in beans.

7. Develop N_2 fixation profiles for drought tolerance selections from CIAT, Mexico and other sources for normal and drought conditions.

8. 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.

9. 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.

10. Use the information and genetic materials obtained in the experimental phases as sources of improved germplasm in variety development programs.

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

B. FY 84 Objectives

1. Complete analysis and summary of field trials at Iguala and Durango, Mexico.

2. Complete analysis of data from the BNF field trial in Michigan.

3. Conduct a rain-out shelter experiment at MSU with two hybrid populations to study the inheritance of plant characteristics thought to be associated with resistance or tolerance to drought stress.

4. Screen germplasm under drought conditions in Durango, Mexico.

5. Conduct studies of root system characteristics in relation to drought.

6. Field test strains of rhizobia in Mexico and in Minnesota.

7. Field test bean selections for BNF in Minnesota.

8. Conduct an experiment to test the hypothesis of remobilization of photo-assimilate from vegetative to reproductive structures following an imposed drought stress. (This substituted for Objective 2.)

III. CHANGE IN FY 84 OBJECTIVES

Objective 3 (II.B above) was not completed as planned although the genetic stocks were planted under the shelter and carried through to maturity. Board of Directors approval was not sought, since this was a question of research management and not a policy matter.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Ms. Catalina Samper, a graduate student researcher with the project, was ill for part of the year.

B. Difficulty in getting equipment purchased in the US delivered to Mexico continued.

C. Excessive rainfall in Durango in summer 1984 necessitated delayed planting and mitigated drought in all field studies at that location.

D. Ing. Jorge Acosta, a graduate student researcher with the project, experienced a two-week delay at the US Immigration Gate in El Paso, Texas because his re-entry permit, provided by the English Language Center at MSU, did not list by name and age each member of his family. This listing is not normally required. Amended permits, sent special delivery to El Paso, did not reach him until two weeks after he and his family were initially detained.

V. PROGRESS TOWARD OBJECTIVES

A. A field experiment, with two levels of water, with and without soil implant granular inoculation, involving twenty-two bean cultivars originating from CIAT, INIA, the University of Wisconsin and Michigan State University was conducted by Ms. Catalina Samper at Iguala, Mexico, in cooperation with INIA personnel and the workers at the INIA station at Iguala. Starch content of selected entries was determined by the INIA cereal chemistry laboratory at Chapingo on samples supplied from Iguala.

Plots were individually irrigated until anthesis, at which time water was withheld from half the plots so as to impose a drought stress at mid-pod fill. The resulting stress, while not severe, significantly reduced yields in most entries and drastically reduced them in several. The principal effect was on single seed weight. One CIAT entry, BAT 85, and two entries from Michigan, 81017 and 61065, were highest yielding based on the geometric mean of yield in well-watered and stressed plots. The Mexican entries, Bayo Madero and Durango 222, were the poorest yielding. The high temperatures at Iguala (daytime maximum in excess of 33°C for much of the flowering and pod-filling period) are thought to be a major factor, inasmuch as these two cultivars were selected for Durango

conditions (elevation approximately 2000 M, where growing season temperatures are considerably less than those at Iguala).

The data from both Iguala and Durango indicate a close relationship between grain yield and changes in leaf and stem dry weights from anthesis to physiological maturity, implying that assimilate storage and remobilization can make a positive contribution to seed yield under late season water stress. Top yielding cultivars were characterized by a long pre-anthesis phase and a high fruit growth rate. The two cultivars with the highest dry matter partitioning ratios were included in the top 20 percent (n=22) of cultivars on the basis of geometric mean yield of stressed and non-stressed plots.

Nitrogen effects were non-significant for reasons not understood.

B. To test, in a more controlled manner, the hypothesis that storage and remobilization of assimilate can, to some extent, buffer yield against an adverse environmental stress such as drought during pod-filling, an experiment was conducted in the glasshouse with two cultivars and two levels of imposed moisture availability.

Two dry bean cultivars, MSU lines N81017 and B790131, previously determined to show a differential tolerance to drought in field trials, were selected for this study. Water was withheld (D) at mid-pod-fill (MPF), defined as fifteen days after flowering, for each cultivar. Sixteen plants per cultivar were labelled with $^{14}CO_2$ at three different stages, flowering (F), MPF and late pod fill (LPF). Half the plants were harvested at twenty-four hours after labelling and half at physiological maturity (PM). The total $^{14}CO_2$ recovered and its distribution among plant parts was used to estimate the proportion of assimilate translocated to seeds.

The proportion of assimilate produced during seed filling that accounted for the increase in seed weight during the same period differed with treatment and cultivar. Current assimilates for the period MPF to PM accounted for 24 percent of the seed weight increment in 81017 under treatment D, 53 percent was accounted for by assimilate produced in the period F to MPF, and 23 percent was attributed to assimilates produced in pre-anthesis and remobilized during seed filling. Under normal watering (N), only 6 percent of seed growth was attributable to assimilates produced during the periods F to MPF.

For cultivar 290131 (the drought-sensitive line) under D, 24 percent of the seed weight increase was attributable to assimilation during F to MPF, and none from pre-anthesis. Under N, current photosythesis alone accounted for the increment in seed weight. Both genotypes, when stressed, remobilized assimilate from vegetative storage sites, primarily leaves, to developing seeds. Remobilization was more pronounced in the drought tolerant line, N81017, the same line that proved highest yielding under irrigation and drought treatments in the Iguala trial.

Thus, these results support the hypothesis that, under adverse environmental effects, remobilization of previously stored photo-assimilate to the seed is enhanced, particularly in certain genotypes

C. Project activities at the University of Minnesota in FY 84 covered the following areas:

1. Evaluate host cultivars for capacity to fix N_2 in symbiosis.

2. Screen additional strains for effectiveness in N_2 fixation and in competitiveness.

3. Study the effects of drought on N_2 fixation. (No results yet available.)

Fifty-six varieties of P. vulgaris selected from previous plantings at Minnesota from materials reported by Dr. F. Bliss (Wisconsin) as either active or weak in N_2 fixation, from Dr. M. W. Adams (Michigan) as promising drought sources or from CIAT were screened for yield under low nitrogen conditions at the Becker sand plain site. It was assumed that yield under these conditions would be dependent on N_2 fixation. While all results are not yet available, the Brazilian varieties, Carioca and Negro Argel, are clearly among the best entries. The Michigan varieties, N81017 and N81002, also performed well. Among the Bliss materials, populations 24.30, 24.63 and 21.15 (selected as weak in N_2 fixation) behaved poorly while 21.58 and 21.19 yielded well. More detailed studies of contrasting materials will be undertaken in FY 85.

More than 120 strains of Rhizobium leguminosarum biovar phaseoli were evaluated for N_2 fixation in Leonard jars in the glasshouse. Superior strains identified in this screening included UMR 1049, 1072, 1112, 1120, 1122, 1148, 1149, 1189, 1191, 1200, 1226 and 1257. Eleven isolates from the first group of strains tested were also evaluated under field conditions, in a site previously sown to Phaseolus vulgaris. Analysis is not yet complete, but it does not appear that responses to inoculation were obtained. Promising strains from the first Leonard jar study are being evaluated for competitiveness using a streptomycin and chloromycetin resistant mutant of UMR 1899 as the control. This strain was identified as highly competitive in nodule formation in 1982-83.

D. A biological nitrogen fixation/cultivar response trial in Michigan consisted of thirty-six entries, navy and tropical black beans. These were grown in two-row plots twenty feet long in eight replications, where four replications received ninety pounds N as broadcast urea, and four replications received soil implant granular inoculum in the row, supplied by the Nitragin Company of Milwaukee, Wisconsin. The soil was sandy-loamy in texture and tested at slightly less than four pounds N/acre.

The thirty-six entries can be divided into four groups: (1) six check varieties and advanced strains, (2) three varieties used in the Wisconsin program as recurrent parents, plus Puebla, the

non-recurrent parent, (3) eleven selections from the Wisconsin program and previously tested in 1982 and (4) fifteen selections from Michigan which also were tested in 1982.

This test had three principal objectives:

1. Measure the extent to which inoculation would substitute for mineral fertilization in check varieties and breeding lines.

2. See how well a set of lines not previously selected for BNF would do in comparison to lines previously selected for BNF potential.

3. See whether any particular line would yield as well under BNF as when N-fertilized.

If yields of inoculated are expressed as a percentage of N-fertilized yields, the values for the groups 1, 2, 3 and 4, respectively, are 75.3, 73.4, 75.1 and 74.1 percent. Clearly, the answer to objective 1 above must be that, under the conditions of this test, inoculation cannot provide sufficient N to replace ninety pounds of N as urea applied broadcast. Inoculation was handicapped in this test because of the extremely dry weather that prevailed at the test site for some seven weeks from planting. By the time natural rainfall occurred, the more active period for BNF had presumably passed.

The top-yielding entry in the test was Wisconsin 21-16, a Porillo-Syntetico derivative, which yielded under N fertilization at the level of 2372.9 lbs/a. Converted to pounds N, this gave 91 pounds N/acre or nearly 96 percent utilization of applied N. Under BNF, Wisconsin 21-16 yielded 1901.7 lbs/a or, in terms of fixed N, 73 lbs/a.

The 1983 yield data clearly show that previously unselected (for BNF) lines such as the fifteen Michigan-derived entries can perform equally, as a group, to a set of previously selected lines such as the eleven Wisconsin entries both at high N-fertilized levels and under conditions of BNF; 397 gms/4 meters as against 388 for the former, and 294 as against 292 for the latter source of N. It is not at all clear what is implied by this finding. There are two possibilities of interest:

1. The adverse weather during the first seven weeks after planting could have prevented the high BNF lines (most of the Wisconsin selections of group 2) from realizing their BNF potential, thus their performance in yield under inoculation was no better than other entries.

2. The other three groups (1, 3, 4), each of which represents or is derived to a large extent from tropical small-seeded black beans, carry sufficient genes for BNF from their ancestry to enable them, on average, to show yields under inoculation not significantly different from those of group 2, the Wisconsin selections. This

is supported, in part, by the fact that both varieties, Fleetwood and Sanilac, neither of which has any immediate tropical black ancestry, were the lowest yielders under BNF in their respective groups. In addition, the low yielders in the Wisconsin group were from backcrosses to Sanilac.

Finally, as for objective 3, the ratios of yield under BNF to yield under N-fertilization were calculated. Those ratios ranged from 52 percent to 98 percent. Only two entries were above 90 percent, one from the Wisconsin group (at 98 percent) and one from the Michigan group (at 96 percent). Mean ratios for groups 1, 2, 3 and 4 were 76, 73, 76 and 75 percent, respectively. Puebla 152, the Mexican black bean which had been used in the Wisconsin program as donor of genes for BNF, yields a ratio of 88 percent (third highest among all thirty-six entries).

E. Mexican graduate student, Ing. Francisco Ibarra, has been studying root system characteristics in relation to water stress responses made by the entire plant. Data are still being analyzed, but some tentative statements can be made. In a greenhouse trial, with cultivars grown for seventeen days in PVC cylinders containing Perlite as a medium, water stress could be imposed in a controlled way. When harvested as seventeen-day old seedlings stressed continuously after day 10, cultivars differed significantly in total dry weight reductions (percent as compared with the control): CIAT BAT47 was reduced by 39 percent, San Juan Select was reduced only 9 percent and MSU N81017 actually gained 9 percent over its well-watered control. Leaf, stem and total top dry weights, leaf areas and leaf expansion rates showed differences among cultivars. Similar differences were noted for root depth, not length, root weight and volume, with N81017 showing gains over its control and San Juan Select showing equivalent or slight gains also.

In a second greenhouse experiment, not yet analyzed, genotypes of three species, namely Phaseolus vulgaris L. (common bean), P. acutifolius L. (tepary bean) and Vigna unguiculata (L.) Walp. (cowpea) were planted in large polyethylene containers filled with a 50/50 mix of sifted silt loam soil and quartz sand. Six liters of water were added to one series to provide a "stored" water supply. Tops were sealed to prevent evaporative losses. In a second series, water was added weekly until a total of six liters had been added. Physiological and root morphological data were recorded. Plants were allowed to grow until wilting was observed, at which time they were harvested. Common beans suffered more severely, followed by tepary and cowpeas, in that order. On stored moisture, most genotypes developed large vegetative structures but subsequently suffered severely when water was depleted. Some genotypes (MSU 61065) developed a more extensive root system under stored water than under weekly irrigation. Root growth of tepary and cowpeas was similar under either water treatment.

The field experiment in Durango has just been harvested and no data are as yet summarized.

F. In Mexico, work at Durango consisted of the following activities:

1. Plant breeding: Sixteen crosses were made involving parents previously selected for drought resistance or high ability for BNF. F_1s were planted under rainfed conditions at Durango, to be harvested in fall 1984.

   Sixty F_2 populations and ninety-one F_4 families were also grown at Durango for selection for drought tolerance. Because of excessive rainfall, no selections were made.

2. Plant physiology: Eight genotypes were planted in replicated trial at F. Madero, near Durango. The purpose of the trial was to determine if physiological and/or morphological traits could be identified that were (are) contributing to drought resistance. Data were taken for root volume and root dry weight at 15, 30, 45 and 60 cm soil depths, plant water potential, stomatal conductance, biomass, soil water content, phenology, yield and components. Again, the unusual excessive rainfall inhibited the relationships to drought.

3. Rhizobium research: From 110 collections made in 1983 in the semiarid highlands of Mexico, 600 strains were isolated and placed in the germplasm bank of the post-graduate college in Chapingo. At this time, 200 of the strains have been evaluated for BNF capacity.

   At Zacatecas experimental station, two field experiments were established with the objective of determining the interaction between ten rhizobial strains and three local bean cultivars with respect to seed yield and d.m. production. Three treatment combinations were included in the experiments: one treatment without rhizobium or fertilizer, one treatment with N and P (30-40-0) and one treatment with P only (0-40-0).

   Data on number, effectiveness, fresh and dry weight of nodules, and on d.m. production were gathered. Soil samples were taken for soil N determinations and natural rhizobium population counts. Data analysis has not been completed.

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use: None.

B. Available for Use Within One to Two Years: Both more efficient N-fixing strains of rhizobium and efficient N-fixing bean strains have been identified. In addition, several bean lines that appear to possess tolerance to drought were identified, particularly in the Durango germplasm evaluation trials. One line from Michigan, N81017, has potential for increase and release as a navy bean cultivar.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
None						
Mexico Citizens:						
Ibarra	M	MSU	Crop & Soils	M.S.		Total
Acosta	M	MSU	Crop & Soils	Ph.D.		Total
Others:						
Samper	F	MSU	Crop & Soils	M.S.	6/84	Partial

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
None					
Mexico Citizens:					
None					
Others:					
None					

Ms. Catalina Samper completed the M.S. and produced a high quality thesis. In further work, she has obtained evidence confirming one major project objective.

VIII. BASELINE DATA

Information has been gathered on yield and N-fixing capability of bean lines--cultivars and advanced selections--under stress and non-stress; yield, plant and seed type and date of maturity for several hundred lines from INIA and CIAT; and N-fixing capability of rhizobial strains under field conditions. All such data are relevant to project objectives.

IX. WOMEN IN DEVELOPMENT

Ms. Catalina Samper has been involved in the project as the initial graduate student. She has conducted a major part of her research in Mexico where women are not usually involved in agricultural research. While she was warmly received by professional colleagues in Mexico and accorded professional respect, it is improbable that her involvement in the project will have impact on women's role in agriculture in Mexico.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO PROJECT

A. United States

1. Personnel

Dr. M. W. Adams, professor, MSU, 10 percent, $14,822
Dr. D. Reicosky, professor, MSU, 10 percent
Dr. P. Graham, professor, UM, 10 percent
Technicians, 10 percent, $1,750
Fringe benefits, $3,996

2. Student training: No US students are currently being trained under this project.

3. Facilities

Research laboratories, offices, greenhouse space, 3,000 square feet
Field facilities at MSU and UM annually, 5-10 acres

4. Materials/supplies: $ 1,000

5. Travel/transportation: $300

6. Indirect costs: $24,868

B. Mexico

1. Personnel

Dr. Rogelio Lépiz, National Coordinator, INIA, 40 percent, $6,000
Technicians, $10,000
Fringe benefits, $3,680

2. Student training

Ing. Ibarra, 100 percent, $10,000
Ing. Acosta, 100 percent, $12,000

3. Facilities (estimated worth to project), $6,000

4. Materials/supplies, $2,000

5. Travel/transportation, $1,000

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages

1. A linkage was established with Native Seeds/Search, Inc. of Tucson, Arizona, a non-profit organization interested in promoting the exploration, evaluation and utilization of potentially useful desert plants.

2. A linkage was also established with Dr. M. Silbernagel, USDA, Prosser, Washington and a Bean/Cowpea CRSP PI (Tanzania project) for the purpose of testing bean lines under a line-source sprinkler system under desert climatic conditions in 1985.

3. A linkage was established with the cowpea program in Brazil, jointly between Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) (Brazil) and IITA (Nigeria). This was effected through the presence at MSU during 1984 of Dr. Earl Watt, IITA cowpea breeder stationed at Goiania, Brazil. Dr. Watt is interested in drought problems in cowpeas and has conducted work during FY 84 on beans and cowpeas. In addition, he spent the month of August 1984 in Durango.

B. On-Going Linkages: Only the MSU/INIA and the MSU/UM/INIA linkages are on-going.

XII. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy

1. United States

a. Inasmuch as the annual project planning conference is scheduled for Mexico in February or March of 1985, any plans stated at this time must be tentative.

In regard to Objective 9 in II.A above, on estimating the genetic parameters of traits related to or conferring differences in drought responses, F_3 and BC_1S_1 populations were developed of four crosses involving MSU line 81017, the top yielder at Iguala and considered drought resistant to some extent, crossed with Mexican and MSU lines that are drought susceptible. Seed of these populations should be sufficient to grow test nurseries in Durango under water-limiting conditions and in Prosser, Washington, in collaboration with Dr. Silbernagel. Here the line-source sprinkler will be utilized, which offers the opportunity of having the same populations under both sufficient and insufficient water during flowering and seed-filling.

If sufficient seed is available, each family will be grown in plots of twenty-four plants each, two meters in length at standard 70 cm row widths in three replications per each level of available soil/applied moisture. Data will be taken on a plot basis for phenological, morphological and agronomic traits and on individual plants within plots for the physiological characteristics.

Data would be analyzed for each cross separately by methods of biometrical genetics.

b. In regard to Objective 5 in II.A above, on the feasibility of selecting for both drought tolerance and BNF in the same population, thirteen parental genotypes (five Mexican, two

Wisconsin, two CIAT, four Michigan) have been selected differing in drought resistance and in BNF capability. Among these, eleven crosses were made and selections taken in F_2 for nodule score. These selections will be re-scored for nodules in the F_3 generation, from which a combined family/individual selection criterion will be used to select one plant only from the top families.

The resulting progeny will be planted in one-meter rows under the rain-out shelter at MSU in summer 1985 for a combined drought/nitrogen deficiency performance trial. It is anticipated that the same or similar materials will be planted in Durango in 1985.

c. At the University of Minnesota, Dr. Graham plans the following activities for FY 85:

(1) Evaluate approximately fifty bean lines for BNF. In 1984, these lines gave indications of being superior fixers in field trials.

(2) Carry out a preliminary evaluation for BNF of some 300-400 bean lines from CIAT's 1984 Ensayo Preliminare.

(3) Screen some fifty rhizobial strains, known to be effective fixers of N, for competitive ability in establishing nodules on selected host genotypes.

(4) Screen approximately fifty Mexican cultivars for differential ability to select among and to form effective symbiosis with different effective rhizobial strains.

2. Mexico

a. In Durango, the study of physiological/morphological characteristics associated with drought responses in eight genotypes, which was attempted in 1984, will be undertaken again in 1985, hopefully with climatic conditions more representative of the normal semiarid status of the region.

b. F_2 populations of the sixteen crosses made in 1984, involving drought resistant selections and the best BNF types, will be grown under rain-fed conditions, hopefully droughted, for purposes of plant type selection and selection of vigorous yielding types, since previous studies show a high correlation between drought resistance and plant vigor.

c. In rhizobial research, screening of the 600 isolates will continue for BNF efficiency, and selected isolates from the first 200 already tested will be field tested at Zacatecas with selected bean cultivars as host genotypes.

B. Training Objectives and Strategy

1. United States: No US students are presently working on this project.

2. Mexico

a. Two students from Mexico are presently involved: One, Ing. Francisco Ibarra, who spent the summer at Durango, returned to MSU November 1 to analyze data and write the M.S. thesis. He is expected to complete the Master's degree by March 31, 1985. After this, he will return to Mexico for assignment by INIA. A second student, Ing. Jorge Acosta, doctoral candidate, will continue with coursework and thesis research during 1985.

b. Ms. Catalina Samper, from Colombia, has completed the M.S. and is presently working as a technician on the project to complete data analysis and write-ups of previous work. Her future with the project depends upon the state of her health and decisions to be made concerning undertaking a doctoral program.

c. A third student from INIA, Mexico, Mr. Alessandro Barron, has applied for admission to graduate study at MSU. His admission is pending review by the Department of Crop and Soil Sciences Graduate Programs Committee.

C. Anticipated Personnel/Locational Changes: None anticipated.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Adams, M. W., Earl Watt and Catalina Samper. 1984. Drought Tolerance in the Common Bean: Possible Regulating Mechanisms and Breeding Strategy. Paper presented at the Symposio Sobre Sequía X Congreso Nacional de Fitogenética, Aquascalientes, Mexico, August 27-31, 1984.

Samper, Catalina. 1984. Effects of Water Stress Imposed at Mid-Pod Filling upon Yield and Dry Matter Partitioning in Dry Beans (Phaseolus vulgaris L.). M.S. Thesis, Michigan State University.

NIGERIA • MICHIGAN STATE UNIVERSITY

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. S. Greenbaum, Department of Medicine, MSU
	Dr. H. L. Sadoff, Department of Microbiology and Public Health, MSU
Contracts and Grants Officer:	Mr. Gerald Jacobs, Contracts and Grants Office, MSU
Board of Directors Delegate:	Dr. Dale Harpstead, Chair, Department of Crop and Soil Sciences, MSU
Institutional Representative:	Dr. James Anderson, Dean, College of Agriculture and Natural Resources, MSU

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

Principal Investigators:	Dr. David Drew,* Department of Pediatrics, University of Jos
	Dr. A. Omololu,** Department of Human Nutrition, University of Ibadan
Co-Principal Investigators:	Dr. Peter Isichei, Department of Pediatrics, University of Jos
	Dr. M. A. Hussain, Department of Human Nutrition, University of Ibadan
	Dr. N. Okere,*** Faculty of Medicine, University of Jos
Associates:	Dr. I. Akinyele, Department of Food Science, University of Ibadan
	Ms. J. Nwokedi, Department of Community Medicine, University of Jos

C. USAID Project Officer: Ms. Keys McManus, US Embassy, Lagos

*Dr. Drew was PI until August 1984 when he resigned to return to England.
**Dr. Omololu was on leave FY 84.
***Dr. Okere moved to another institution during FY 84.

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives

1. Explore a possible relationship between eating cowpeas and gastrointestinal problems in young children.

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

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

B. FY 84 Objectives: The three general objectives were pursued during FY 84.

III. CHANGE IN FY 84 OBJECTIVES: None were necessary.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. This project has been adversely affected by difficulties in communication between Nigeria and the US and by changes in the composition of the research teams. Dr. Akpom, who originated the project, retired; Dr. Omololu, the PI of the Ibadan team, went on extended leave; Dr. Drew, the PI of the Jos group, resigned in August 1984 to return to the United Kingdom; and his Co-PI, Dr. Okere, moved to another institution.

B. The survey in localities around Ibadan was handicapped by the lack of a vehicle assigned to the project, and recently a portable electrical generator which was necessary for the human feeding experiments in Ibadan broke down.

V. PROGRESS TOWARD OBJECTIVES

A. The rather extended surveys completed this year constitute significant progress. Although the results of the circa 2,000 interviews with families have not been fully scrutinized yet, it appears that in Nigeria approximately ten percent of the children in the age range of six to twenty-four months react adversely to the consumption of cowpeas, at least according to the perception of their mothers. The main symptom is diarrhea.

B. Experiments in which susceptible and control children are fed cowpeas under supervision are still in progress.

C. As discussed below under Section VI.4, breath hydrogen tests with adults clearly indicate that ingestion of cowpeas results in a large increase in breath hydrogen excretion.

D. New methodology for the testing of lectins in cowpeas is being sought.

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use

1. The survey work commenced a year ago around the towns of Ibadan and Jos continued this year. At Ibadan, analysis of 855 questionnaires filled out by mothers with the help of trained interviewers indicated that 63 children experienced gastro-intestinal (GI) problems following the ingestion of cowpeas, while 792 children who also ate cowpeas were free of such problems. It appeared that:

   a. Younger children were more susceptible to cowpea-related GI distress (mostly diarrhea) than older children.

   b. Greater frequency of cowpea intake (within three days) resulted in higher likelihood of GI distress.

   c. The incidence of GI disorders as a result of cowpea ingestion disappeared at the child grew in age.

2. The results of an experiment in which thirty-four control or non-reacting children and thirty-four susceptible children were fed weighed quanitites of cowpeas under medical supervision have not yet been analyzed.

3. At Jos, a similar survey indicated that thirteen percent of the families interviewed reported GI problems in children who ate cowpeas, with diarrhea again being the most common symptom. Another four percent of the families reported cowpea-related GI distress among adults. Further analysis of the questionnaires indicated that the GI problems attributed to cowpea consumption were not statistically related to socio-economic status, educational level, method of cooking cowpeas and feeding practices. The results of another two hundred families interviewed for the same purposes have not yet been reported.

4. At MSU, two studies are being conducted, one dealing with the amount of exhaled hydrogen following the ingestion of cowpeas and the other being an attempt to measure the lectins (hemagglutinins) present in cowpeas. The concentration of hydrogen in the breath has been correlated to the volume of flatus. Gas generation in the gut is mainly attributed to undigestible diet carbohydrates which are fermented in the lower intestine.

   In the breath hydrogen study, two adult female subjects ingested on different days 100g, 150g and 200g of cowpeas prepared as ewa-ibeji (boiled whole cowpeas) or as moin-moin (steamed dehulled cowpeas), and the exhaled hydrogen was measured by means of a hydrogen breath analyzer (Quintron Company, Milwaukee) at half-hour intervals for eight to ten hours postprandially. The amount of exhaled hydrogen started increasing about three hours after the meal and peaked at about the fifth or sixth

hours. At that time, the concentration of hydrogen in the exhaled air was ten to twelve times greater than at zero time. The excretion of hydrogen in the breath continued at a lower rate even after the eighth hour. A meal based on rice did not result in any respiratory rise of hydrogen. The method of preparation of the cowpea meals did not appear to affect the excretion rate of hydrogen. While increased intake of cowpeas resulted in increased excretion of breath hydrogen, the increase in hydrogen concentration was not proportional to the size of the cowpea meal.

B. Available for Use Within One to Two Years: The following outputs are expected within the next two years.

1. Confirm the untoward symptoms observed by certain mothers in children fed cowpeas.

2. Identify the factors in cowpea diets which cause these symptoms.

3. Attempt to remove the diet factors related to the adverse symptoms.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
None						
Nigerian Citizens:						
Ogun	F	MSU	Food Science	Ph.D.		Total
Others:						
Martinez	M	MSU	Food Science	M.S.		Partial

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
None					
Nigerian Citizens:					
None					
Others:					
None					

The project fully supports one Nigerian graduate student, Ms. Phillipa Ogun. She initiated her doctoral program at MSU in March 1983, and she will strive to complete it in three years. Her research deals with the

nutritional aspects of cowpeas. A number of Nigerian students were trained at the University of Ibadan and Jos for the task of interviewing families and monitoring feeding experiments with children in connection with this project.

VIII. BASELINE DATA

This research program was initiated on the basis of unconfirmed reports by Nigerian physicians, especially Dr. A. Akpom, the first PI of the project, that young children, six months to two years of age, suffered from diarrhea when they consumed cowpeas.

IX. WOMEN IN DEVELOPMENT

Two women play cardinal roles in this project. One is a Co-PI of the MSU team, and the other is a Nigerian doctoral candidate devoting all her research effort to this project. A number of young women in Nigeria have also been trained to conduct nutritional surveys.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO THE PROJECT

A. United States

1. Personnel: The PI of the MSU team, Dr. Markakis, contributed approximately 20 percent of his time to this project and the Co-PI, Dr. Chenoweth, 10 percent of her time. The associate, consulting faculty, Drs. Greenbaum and Sadoff, offered 0-5 percent of their time. Value: $12,000.

2. Student Training: Academic guidance was provided to a doctoral candidate, Ms. Ogun, who studies at MSU under the auspices of this project.

3. Facilities: Laboratory space and MSU facilities were provided for the work performed at MSU.

B. Nigeria

1. Personnel: It is estimated that the previous PI of the Jos team, Dr. Drew, contributed 10 percent of his time to the project, and the Co-PI, Dr. Isichei, 2-5 percent of his time. The PI of the Ibadan team, Dr. Omololu, was on sabbatical leave last year, but his co-workers, Drs. Hussain and Akinyele, contributed at least 10 percent of their time to the project.

2. Facilities: The Nigerian teams provided space in clinics, as well as kitchen and laboratory facilities for their work on the project.

3. Travel: Nigerian team members also traveled extensively to the villages where the children under study live.

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages: In addition to cooperating with the Nigeria/Univer of Georgia Bean/Cowpea CRSP team, a linkage was established with Iowa State University where extrusion work on cowpeas is performe (under Dr. Mark Love) independently of the Bean/Cowpea CRSP.

B. On-Going Linkages: This project is a collaborative undertaking between the Universities of Ibadan and Jos in Nigeria and Michiga State University. The teams of these three institutions exchange information with the University of Nsukka, which conducts a socio economic study of cowpeas in Nigeria and with the Nigeria/Univers of Georgia Bean/Cowpea CRSP project, which is investigating certa technological aspects of cowpeas.

XII. FY 85 PROPOSED PLAN OF WORK

This project will proceed along the lines originally established. Th survey results, which show that a small proportion of young children react adversely to cowpea intake, will be supplemented with controlle feeding tests. These are already in progress. The breath hydrogen studies with adults will continue in order to secure sufficient data statistical analysis. The study of anti-nutritional factors (lectins, trypsin inhibitors and undigestible oligosaccharides) in cowpeas will continue. Ultimately, genetic, physical, chemical and/or biochemical means of removing the offending constituents from cowpeas will be sou

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

None.

NIGERIA • UNIVERSITY OF GEORGIA

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 (UGA)

Principal Investigator:	Ms. Kay H. McWatters, Department of Food Science, UGA
Co-Principal Investigators:	Dr. Larry R. Beuchat, Department of Food Science, UGA
	Dr. Manjeet S. Chhinnan, Department of Food Science, UGA
	Dr. Robert D. Phillips, Department of Food Science, UGA
	Dr. Robert E. Worthington, Department of Food Science, UGA
Research Technician:	Ms. Joy Adams, Department of Food Science, UGA
Laboratory Technicians:	Mr. Glen Farrell, Department of Food Science, UGA
	Mr. Igor Choodnovskiy, Department of Food Science, UGA
	Mr. Larry Hitchcock, Department of Food Science, UGA
	Mr. Gary Burch, Department of Food Science, UGA
	Ms. Addie L. Branch, Department of Food Science, UGA
	Ms. Brenda Nail, Department of Food Science, UGA
	Ms. Katrina Benton, Department of Food Science, UGA
Department Head:	Dr. Tommy Nakayama, Department of Food Science, UGA
Business Officer:	Mr. Ted Proffer, College of Agriculture Business Office, UGA
Contracts and Grants Officer:	Mr. Robert Wallace, UGA Research Foundation
Institutional Representative:	Dr. Charles W. Laughlin, Associate Director of the Agricultural Experiment Stations, UGA

B. Nigeria Counterpart Institution: University of Nigeria, Nsukka

Principal Investigator:	Dr. Patrick O. Ngoddy, Dean, Faculty of Agriculture, and Professor, Department of Food Science and Technology, University of Nigeria, Nsukka
Co-Investigators:	Dr. Zak O. Obanu, Head, Department of Food Science and Technology, University of Nigeria, Nsukka

Dr. George S. Ayernor, Department of Food Science and Technology, University of Nigeria, Nsukka
Dr. Nwachukwu D. Onwuka, Department of Food Science and Technology, University of Nigeria, Nsukka
Mr. Dickson O. Nnanyelugo, Head, Department of Home Science and Nutrition, University of Nigeria, Nsukka
Ms. Veronica I. Onuorah, Department of Home Science and Nutrition, University of Nigeria, Nsukka
Dr. Ikemefuna C. Obizoba, Department of Home Science and Nutrition, University of Nigeria, Nsukka
Ms. Jean King, Department of Home Science and Nutrition, University of Nigeria, Nsukka
Dr. Azuka Dike, Department of Sociology/Anthropology, University of Nigeria, Nsukka
Dr. Emea Arua, Department of Rural Sociology, University of Nigeria, Nsukka

C. USAID Project Officer: Ms. Keys McManus, US Embassy, Lagos

II. PROJECT OBJECTIVES

A. Overall (Five-Year) Objectives

1. Assess patterns of cowpea utilization in Nigeria and elucidate the associated socio-cultural and socio-economic factors.

2. Develop a package of appropriate technologies adapted specifically to address identified constraints to cowpea utilization.

3. Develop policy guidelines to foster efficient utilization of cowpeas through the promotion of consumption, rural industries and the associated linkage to rural/urban markets and to farming activities in rural areas.

B. FY 84 Objectives

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.

III. CHANGE IN FY 84 OBJECTIVES: None.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Administrative burdens associated with project management, budgetary/accounting matters and efforts to assure the safe delivery of equipment to Nigeria require an inordinate amount of the US team's time and appear to have no prospect of diminishing.

B. The slow process in obtaining approval from USAID to purchase necessary equipment items impedes progress and delays the expenditure of project funds. This situation influences spending activity which, in turn, directly influences future budget allocations. The University of Georgia is still awaiting approval of six items of equipment which were requested in March 1984, all of which are manufactured in the US and, therefore, do not require source-origin waivers.

C. No progress has been made in locating a variable speed motor which was shipped to Nigeria in August 1982 and needed to operate an abrasive dehuller. Regrettably, neither the manufacturer nor the freight forwarding company followed procurement instructions to notify the Nigerian PI in advance of the shipment. Efforts to locate the motor through the Nigerian Airport Authority and Iberia Airlines have required much time and effort on the part of the University of Nigeria and thus far have been fruitless.

D. For the University of Nigeria, the process of requisitioning and importing items of equipment from the US has been slow, and difficulties associated with foreign exchange continue to pose problems for the country.

E. Communication continues to be a problem. Slow mail service, poor to non-existent telephone service, non-existent Telex service at the University of Nigeria and the uncertainty of messages being

received by Nigerian personnel contribute to the problem. This creates difficulties in receiving timely contributions to annual reports and budgets.

V. PROGRESS TOWARD OBJECTIVES

A. University of Georgia, Project-Specific Progress

1. Methods for enumerating yeasts and molds, with particular emphasis on aflatoxigenic Aspergilli: Two microbiological media were evaluated for suitability to support growth of yeasts and molds naturally present on cowpeas and in cowpea flour. In addition, the performance of these media with regard to their ability to aid in the detection of potentially aflatoxigenic Aspergillus flavus and Aspergillus parasiticus was examined. Neither medium appears to be adequate for use in enumerating total viable populations of yeasts and molds.

2. Aflatoxin production on cowpeas: Experiments were conducted to determine the suitability of whole cowpeas and cowpea flour for supporting growth and aflatoxin production by Aspergillus flavus. Preliminary results indicate that aflatoxin can be produced on whole cowpeas and flour if the temperature and moisture contents are adequate. Studies are still in progress.

3. Cowpea storage studies

   a. Effect of cowpea storage conditions on water absorption, cooking properties, sensory quality and mycological quality: Cowpeas containing ca. 12 percent moisture were stored in open containers, high density polyethylene and laminated plastic (curlon 550) bags at 2°C, 21°C and 35°C. Seed in plastic bags was flushed with CO_2 before heat sealing. All seed stored at 35°C (65 percent R.H.) developed the hard-to-cook condition. After 10 months of storage the texture values of cooked peas (boiled 40 min) were 12.9, 15.3 and 18.7 Newtons/gram (N/g) for peas stored in open containers, high density polyethylene and laminated plastic, respectively. Comparable values for seed stored at 2°C were 6.2, 5.2 and 5.5, respectively. Decreases in water absorption values were also observed. Carbon dioxide atmosphere (exclusion of oxygen) did not prevent development of the hard-to-cook condition.

      Storage of cowpeas at 2°C resulted in protection of yeasts and molds against loss of viability. Storage at 21°C and 35°C caused rapid death of fungi. After 10 months at 2°C, populations were highest in samples stored in high-density polyethylene and laminated plastic bags, suggesting that retention of volatiles from seeds within these containers may have afforded protection against inactivation. From the results obtained, rapid death of yeasts and molds would be expected to occur, regardless of type of storage containers, if cowpeas were to be stored at ambient temperature in Nigeria and under conditions of 65 percent relative humidity

or less. Microbiological spoilage under these conditions would not occur.

b. Effect of storage on dry-dehulling efficiencies: Cowpeas stored in six selected environmental conditions were chosen to study the effect of five-month and ten-month storage periods on dry-dehulling efficiencies. Percent of dehulled cowpeas with the hilum completely removed increased with the increase in storage period and storage temperature. Storage period, however, had a more pronounced effect than temperature. Although no general pattern was observed in values of percent undehulled seeds, the values estimated for cowpeas stored at 35°C and ten months were lower than those stored at 35°C and five months.

c. Physical and sensory characteristics of akara processed from stored cowpea seeds: Cowpeas stored for ten months under environmental conditions described earlier (Section V.A.3.a) were evaluated for akara processing quality. Akara, a popular West African food prepared from cowpea paste, was made from whole seeds (traditional process) and from meal. Effects of storage on paste and akara characteristics were more apparent in products made from whole seeds than meal. Storage effects were also more pronounced in physical characteristics (paste viscosity, akara shear force, akara composition) than in sensory characteristics. More quality characteristics were affected when seeds were stored at 35°C than at 2 or 21°C.

4. Electronic bean/cowpea cookability tester: Development of a prototype model of this device was reported in the Bean/Cowpea CRSP 1983 Annual Report: Technical Summary. The device was partially redesigned to alleviate frequent malfunctioning of electronic switching components. The new device has performed satisfactorily under extensive testing trials. It will be used in further studies related to the hard-to-cook phenomenon which may develop in cowpeas during storage.

5. Pretreatment of cowpeas to improve dehulling efficiency: Ms. Laila Hudda, an M.S. degree student partially supported by the project, observed a tremendous improvement in dry dehulling efficiency when cowpeas were subjected to wet and dry pre-dehulling treatments. She did not investigate the influence of pre-dehulling treatments on the functional properties of cowpeas. Peas subjected to high-temperature (100°C) drying and processed into meal exhibited poor foaming and flowability characteristics of cowpea paste and poor quality akara. New experiments have been designed to employ pre-dehulling treatments involving drying temperatures lower than 100°C. A used clothes dryer has been modified to conduct these tests under constant drying temperatures.

B. University of Georgia, Project-Related Progress

1. Textural characteristics of extruded cowpea, sorghum and peanut blends: An extensive investigation of the effects of composition, feed moisture and barrel temperature on sensory and rheological properties of extruded blends of cowpea, sorghum and full-fat peanuts revealed that cowpea-sorghum blends were more difficult to extrude into a snack-like product than either commodity alone. A mixture of 67 percent cowpea-33 percent sorghum produced a more acceptable product than the 67 percent sorghum-33 percent cowpea combination. Blends containing 30 percent peanut or 15 percent peanut and 28 percent cowpea could not be extruded. Further efforts are required to produce acceptable extruded snacks from blends containing cowpea meal.

2. Effects of extrusion on solubility and electrophoretic behavior of cowpea proteins: Effect of extrusion on cowpea proteins was investigated by sequential extraction in solvents of increasing dissociating power and gel electrophoresis. Results indicate that extrusion denatures native cowpea proteins, converting them into non-covalently and disulfide bonded networks.

C. University of Nigeria

1. Laboratories are now equipped, through acquisitions made possible by Bean/Cowpea CRSP funds, to tackle the project's scientific and technological challenges. This was achieved over three years with a substantial proportion of the equipment installed only in 1983-84.

2. The generation of physical property data on cowpea flour and its fractions is making steady progress and can be completed since two equipment items (an Instron Universal Tester and a Brookfield viscometer) were received and installed.

3. The correlation of physico-chemical properties with sensory attributes is in progress.

4. Cowpea dehulling technology in both software and hardware has been developed over the period of three years. With the successful installation of four mechanical devices, performance-evaluation of these devices is now on firm technical footing and is progressing very well.

5. The socio-cultural and socio-economic survey instrument, developed in 1981-1982, was successfully field-tested in 1983. Analysis of data from the field test is in progress.

6. The nutrition survey and nutrition/assessment instruments and methodologies were developed and tested. The nutritional status of the cowpea in one area of Anambra State was defined using these instruments.

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use

1. Results from experiments conducted at the University of Georgia designed to enumerate Aspergillus flavus in cowpeas and in cowpea flour reveal that Aspergillus flavus/parasiticus medium is most suitable. This medium is recommended for use by microbiologists interested in monitoring cowpeas for the presence of potentially aflatoxigenic strains of these molds.

2. A socio-cultural and socio-economic survey instrument was developed and field tested in Nigeria. It is available for immediate and longer-term application to address the various socio-cultural and socio-economic questions relating to cowpea utilization in Nigerian communities. The instrument includes a questionnaire, staff training and an analytical frame for interpreting data in relation to (1) the cultural, social and economic importance of cowpeas in selected Nigerian communities and (2) analysis of the potential impact of technological innovation on cowpea usage patterns with particular reference to its impact on the lives of women and children in rural areas and among the urban poor.

3. A nutrition survey instrument was developed and field tested by the University of Nigeria. It is now available for application and has been effectively applied in examining the nutritional status of selected communities in Nsukka Local Government Area and the role of cowpea in community nutrition and community eating habits.

4. Formulation and assessment of weaning food blends involving cowpeas were undertaken at the University of Nigeria and have provided insights regarding the utilization of cowpea meals in infant food formulas.

5. A process was perfected and is available for immediate application for loosening cowpea seed coat so that the grains are easily and efficiently dehulled in the dry form. The process involves wetting and dry-tempering. Necessary software and hardware were developed and are available for immediate application.

B. Available for Use Within One to Two Years

1. There are four mechanical devices at an advanced stage of performance-testing and evaluation for the dehulling of tempered cowpeas. A complete package of dehulling technology suitable for application in a rural industry will be available within one year.

2. Data on the physico-chemical characteristics of cowpea starch, protein and flour in relation to their gelation, swelling and pasting propensities were compiled. For objective evaluation

of cowpea products, these physico-chemical properties are being correlated with sensory attributes of traditional cowpea foods. The package of techniques and data will be available in one to two years.

3. The extrusion of decorticated cowpea meal to products with a variety of textural properties was demonstrated on a pilot-lab scale machine. The production of consumer-acceptable foods should be possible using this technique. Further work is needed to (1) select a targeted food type, e.g. snack, and optimize its textural characteristics, (2) investigate the inclusion of an acceptable flavor base in the product and (3) demonstrate scale-up to small production machines practical at a village/small town level. The development of extruded cowpea-cereal blends with acceptable textural characteristics appears to require a more intensive research effort but should probably be a longer-term goal.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
Falcone	M	UGA	Food Sci.	M.S.	12/83	None
Baker	F	UGA	Food Sci.	M.S.	12/83	Total
Schaffner	M	UGA	Food Sci.	M.S.		None
Nigeria Citizens:						
Nnanna	M	UGA	Food Sci.	Ph.D.		Total
Ahamba	F	U.Nigeria	Food Sci.	B.S.		Partial
Ofo	M	U.Nigeria	Food Sci.	B.S.		Partial
Onuabuchi	F	U.Nigeria	Food Sci.	B.S.		Partial
Others:						
Hudda	F	UGA	Food Sci.	M.S.	12/83	Partial

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
Stewart	M	UGA	C. dehull.tech.	UGA	13 weeks
Weems	F	UGA	Rapid analysis of c. moisture content	UGA	12 weeks
Nigeria Citizens:					
Obizoba	M	U.Nigeria	Cowpea phytate & fiber analysis	UGA	One week
Nnanna	M	UGA	MSTAT Wkshp.	MSU	One week
Others:					
None					

Information on these students' work follows:

Ms. Elizabeth A. Baker's thesis work examined the nutritional quality of cowpea meal, raw and cooked by traditional and novel methods, using rat feeding methods as well as amino acid analysis and in vitro digestibility.

Mr. Richard G. Falcone investigated the production of novel extruded snack-like foods from mixtures of cowpea, sorghum and peanut meals and subsequently characterized these products using sensory and rheological methods.

Ms. Laila B. Hudda's thesis work investigated the mechanical dehulling of cowpeas (Vigna unguiculata) using wet and dry methods.

Mr. Ifendu Nnanna's Ph.D. research will address the reduction oligosaccharide content of cowpeas by combinations of soaking and sprouting, and possibly exogenous enzyme action, and the resulting effects on functional and nutritional quality of the products.

Mr. Donald W. Schaffner's thesis title is "Comparison of Aqueous Extracts of Cowpeas, Soybeans, Peanuts and Sorghum as Substrates for Producing Yoghurt-like Products by Lactic Acid Bacterial Fermentation."

Ms. Carmenita Weems obtained data to develop a procedure for rapid determination of the moisture content of cowpeas using a Microwave Moisture Analyzer. A senior from the local high school, she worked under the USDA Minority Apprenticeship program.

Mr. James B. Stewart, an undergraduate, worked developing cowpea dehulling technology. He was fully supported by Bean/Cowpea CRSP funds.

In fulfillment of requirements for the B.S. degree in food science and in home science/nutrition at the University of Nigeria, a number of students have been involved in project-specific or project-related studies since the project was initiated in 1981. The three currently enrolled are listed above. Other students from previous years were not included in reporting and, hence, are listed here:

Uzo, Francisco N. A. June 1981. Dehulling of Cowpeas (Vigna unguiculata).

Simon, Onoja Uwakwe. June 1982. Dehulling of Cowpeas (Vigna unguiculata).

Offot, Udo. June 1982. Structural Characteristics of Moin Moin.

Adani, Leigh. July 1982. Nutrition Value of Legume Grains as Evaluated with Weanling Rats.

VIII. BASELINE DATA

A socio-demographic/nutritional status survey of 250 low-income households in the Nsukka area was conducted by the University of Nigeria team. Data were collected to (1) determine consumption, purchasing, processing and storage patterns of cowpeas in the Nsukka area of Anambra State; (2) determine the adequacy and contribution of cowpea to the nutrient intakes of preschool children and pregnant women in the Nsukka area; (3) construct a market price index of cowpeas, other legumes and other common foodstuffs, based on quarterly prices at Nsukka market; and (4) determine the nutrient content of common local dishes made from cowpeas and other legumes. This study confirmed the importance of cowpeas in the diet of the community and provides baseline data against which the effects of cowpea processing, storage and utilization technologies can be evaluated.

In addition, information on available technologies for decorticating cowpeas has been compiled. It is from this collection that process technologies have been selected for evaluation and potential application in Nigeria. Quality data on popular varieties of cowpeas are also being compiled by the University of Nigeria.

IX. WOMEN IN DEVELOPMENT

The primary objective of this research project is to develop appropriate storage and processing technologies to increase the availability of cowpeas and to encourage increased utilization of cowpeas among Nigeria's rural population and urban poor. As producers, sellers, processors and consumers of cowpeas, women are primary beneficiaries of project research. Female investigators, technicians and students are involved in the research.

A. University of Georgia: Ms. Kay McWatters continues in her role as Principal Investigator. Her research activities include assessing effects of storage and processing on functional and sensory characteristics of cowpea products. Seven female technicians (non-CRSP supported) provided technical assistance during FY 84. Two females were suppported either partially or totally by CRSP funds for M.S. degree training. Another female (non-CRSP supported) was involved in project research activities as part of a non-degree training program.

B. University of Nigeria: Ms. Veronica Onuorah, co-investigator, continues to assume major responsibility for two important aspects of the project--evaluation of the performance of cowpea meal as a principal ingredient in traditional West African dishes and sensory evaluation of foods prepared from cowpea meal. Ms. Jean King, co-investigator, is actively involved in collection of data for the household consumption profile survey for cowpeas and for the market price index of common food items including legumes. Both activities are being conducted in the Nsukka area. Over the course of the project, several female B.S. students have conducted special projects pertaining to cowpea processing technology or nutrition. Ms. Nwechi Onah, a teaching assistant, plans to pursue an M.S. degree in sociology on some aspect of the project.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO THE PROJECT

A. University of Georgia: Personnel (Salaries + Staff Benefits)

Dr. L. R. Beuchat, professor, 39 percent, $15,627.24
Dr. R. D. Phillips, associate professor, 33 percent, $15,467.86
Dr. M. S. Chhinnan, assistant professor, 31 percent, $13,511.39
Ms. Kay H. McWatters, agricultural research scientist, 16 percent, $6,234.54
Total $50,841.03

B. University of Nigeria: Although Host Country institutions are not required to cost share, the University of Nigeria has contributed substantial resources to the project. It has given two grants in the form of matching awards to augment the collaborative grant. The first grant (1981) was for the nutritional assessment of food legumes in the amount of ₦35,000 ($60,000). The second grant (1983) was an equipment grant of ₦50,000 ($75,000) to equip laboratories of the participating departments, thereby improving research capabilities. Additionally, personnel time and administrative support have been amply given. Also, the University of Nigeria has absorbed most of the cost of student time inputs. Estimates of support, in addition to the two grants mentioned above, were $25,000 per year for two years.

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages

1. University of Georgia: Papers describing project research were presented at professional scientific meetings. Two members of the Bean/Cowpea CRSP team, Drs. R. E. Worthington and L. R. Beuchat, are involved in storage and microbiological research activities with the Peanut Collaborative Research Support Program.

2. University of Nigeria: The primary linkages have been with village communities in which socio-economic/cultural and nutritional surveys were conducted. Linkages have also been established with IITA and the National Cereals Research Institute, Ibadan, Nigeria.

B. On-Going Linkages: The US and Nigerian institutions continue to follow the progress of other Bean/Cowpea CRSP utilization projects (INCAP/Washington State University (WSU)/Swanson and Nigeria/Michigan State University (MSU)/Markakis). Joint interest in the hard-to-cook phenomenon may result in a stronger linkage between the UGA and WSU projects. Although IITA has no utilization emphasis in its grain legume research program, Dr. S. R. Singh, Program Director, continues to offer the resources of IITA to CRSP utilization projects.

Dixiecream cowpea seed grown at UGA was sent to Dr. Florence Dovlo, Food Research Institute, Accra, Ghana to determine production potential in that country. This cream-type seed has little pigmentation in the hilum region and can be used for akara processing without dehulling.

II. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy

1. University of Georgia

a. Microbiology studies of cowpeas: Studies to determine the suitability of cowpeas as substrates for aflatoxin production will continue. The influence of interacting effects of moisture content, temperature and time on growth of Aspergillus flavus on cowpeas will be further investigated.

While it is essential to know the influence of moisture, temperature and time on microbiological stability of dry cowpeas and cowpea flour, it is also important to determine microbiological changes which might occur in cowpea paste under conditions which might occur in the marketplace or in the home. Once pastes are prepared, they may set for as long as ten to twelve hours before being fried and consumed. This is especially true in the marketplace. Investigations of the changes in microbiological profiles of such pastes appear to be a necessary part of the total project. Experiments will be initiated in FY 85 to determine the main groups of micro-organisms which are likely to proliferate during extended periods of holding cowpea paste before frying to prepare akara.

b. Cowpea storage studies: Cowpea flour, produced utilizing the optimum conditions of preconditioning and milling, will be adjusted to two moisture levels (6 percent, 12 percent) and stored in high density polyethylene bags at three temperatures (-18°C, 21°C, 37°C). Samples will be removed at five, ten, fifteen and twenty months and evaluated for foam volume, viscosity, water absorption, color, percent moisture and microbial populations. Selected samples of stored seeds and meals will be evaluated in terms of amino acid profile and in vitro digestibility. Changes in protein solubility during storage will be assessed by measuring sequential extractability of protein into buffer, buffer-SDS and buffer-SDS-mercaptoethanol. These changes will be related to changes in functionality of the meals upon storage. Similar evaluations will also be made at initiation of the study.

c. Cowpea dehulling studies: Effect of pre-dehulling treatments of cowpeas, involving moisture adjustment of 20-30 percent and drying at constant temperatures of 50 to 80°C, on dehulling characteristics will be investigated. Cowpea meal will be made from pretreated dehulled seeds. Physical and

chemical properties of cowpea meal such as color, available lysine, protein solubility and water absorption will be determined. Foam volume and viscosity of paste prepared from cowpea meal will also be investigated. Appropriate data will also be collected to estimate energy requirements for various promising processes to make meal from whole seeds.

2. University of Nigeria

a. Analysis of socio-cultural and socio-economic survey data will be completed. In conjunction with the nutritional survey data, a clear picture will be constructed of the cowpea's role and importance in the nutritional, social, economic and cultural patterns of the communities involved. Both survey instruments used in the Nsukka area will now be applied in a comparative study of the Onitsha urban area to widen the scope of analysis.

b. With the installation of the Instron Universal Tester and viscometric instruments, great emphasis will be placed on advancing the course of generation of physico-chemical data and on the related sensory attributes of cowpeas, cowpea flour and cowpea-based foods.

c. A complete package of cowpea flour manufacturing technology in prototype will be assembled to include the following unit operations: (1) pre-dehulling, (2) mechanical dehulling, (3) cleaning/separation to obtain clean, dehulled grain cowpeas, (4) flour milling, (5) flour packaging. This prototype will be operated and evaluated technically and economically as a basis for transferring the technology to a rural industry. Plans for installation of a demonstration mill at the village level are being developed.

d. Dr. I. C. Obizoba proposes to examine the effects of cooking and decortication on the phytic acid, protein, fiber and mineral (specifically copper, zinc and calcium) contents of cowpeas and correlate these observations to changes in nutritional quality as determined in feeding studies. Nutritional quality will be assessed in rats by growth (protein efficiency ratio [PER]), true digestibility of protein and mineral and vitamin balance studies. One student will be responsible for the analytical determinations and another for the nutritional studies.

e. Dr. G. S. Ayernor has treated blackeye and Kano white cowpea varieties by soaking for various times followed in some cases by sprouting then sun drying. Analyses proposed for these samples include functionality (soluble nitrogen, foam formation, texture/rheology) sensory [beany odor], chemical (proximate analysis, total soluble carbohydrate, total sugars) soluble protein, total protein, protein quality (amino acid profile, digestibility, PER) and enzymology (amylase activity [pH 5.1-5.5], proteolytic enzyme activity).

B. Training Objectives and Strategy

1. University of Georgia

a. Training activities which are in progress for Mr. Ifendu Nnanna and Mr. Donald Schaffner are discussed in Section VII.A.

b. Ms. Marlene A. Bulgarelli will initiate a Ph.D. program in food science. Her research topic will encompass studies to determine changes in microbial flora which take place during storage of akara paste. Changes in functional properties and nutritional characteristics will also be addressed.

2. University of Nigeria

a. It is anticipated that students will continue to be involved in research programs which parallel the major emphases of the project for which the Nigerian institution has primary responsibility.

b. Ms. Nwechi Onah plans to pursue a M.S. degree in sociology on some aspect of the project.

c. Students will be responsible for analytical determinations and nutrition studies associated with Dr. I. C. Obizoba's research.

C. Anticipated Personnel/Locational Changes: None.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Baker, Elizabeth A. 1983. Protein Quality of Raw, Extruded and Drum-Dried Cowpea Meals as Determined by in vivo and in vitro Methods. M.S. Thesis, University of Georgia, Athens.

Beuchat, L. R. 1984. Comparison of Aspergillus Differential Medium and Aspergillus flavus/parasiticus Agar for Enumerating Total Yeasts and Molds and Potentially Aflatoxigenic Aspergilli in Peanuts, Corn meal and Cowpeas. Journal of Food Protection 47:512-519.

Beuchat, L. R. 1984. Survival of Aspergillus flavus Conidiospores and Other Fungi on Cowpeas During Long-Term Storage Under Various Environmental Conditions. Journal of Stored Product Research 20:119-123.

Beuchat, L. R. 1984. Indigenous Fermented Foods. In H. J. Rehm and G. Reed (eds.), Biotechnology, Weinheim, Federal Republic of Germany: Verlag Chemie International, Vol. 5, Chapter 11, pp. 477-528.

Falcone, Richard G. 1983. Textural Characteristics of Extruded Cowpea, Sorghum and Peanut Blends. M.S. Thesis, University of Georgia, Athens.

Falcone, R. G., R. D. Phillips, M. S. Chhinnan and R. L. Shewfelt. 1983. Textural Characteristics of Extruded Cowpea, Sorghum and Peanut Blends. 68th Annual Meeting, American Association of Cereal Chemists, Kansas City, MO, October 30-November 3, 1983 (Abstract 181).

Hudda, Laila B. 1983. Mechanical Dehulling of Cowpeas (Vigna unguiculata) Using Wet and Dry Methods. M.S. Thesis, University of Georgia, Athens.

Hudda, L. B. and M. S. Chhinnan. 1984. Mechanical Dehulling of Cowpea Using Wet and Dry Methods. 81st Annual Meeting, Southern Association of Agricultural Scientists, Nashville, TN, February 5-8 1984 (Abstract, Food Science and Human Nutrition Section Program, p. 4).

Hudda, L. B. and M. S. Chhinnan. 1984. Improving Dry-Dehulling Efficiency of Cowpeas (Vigna unguiculata) by Wetting and Drying Pre treatments. 44th Annual Meeting, Institute of Food Technologists, Anaheim, CA, June 10-13, 1984 (Abstract 175).

McWatters, K. 1984. A Collaborative Research Project to Improve Cowpe Preservation and Processing in Nigeria. The Georgia Home Economist 35(3):7.

McWatters, K. H. 1984. Improving Food Accessibility Through Village-Level Production of Cowpea Meal. Research Highlights, I(4). East Lansing, MI: Michigan State University, Bean/Cowpea CRSP Management Office.

McWatters, K. H. 1984. Potential Applications for Utilizing Legume Flours in Foods. 65th Annual Meeting, Georgia Home Economics Association, Jekyll Island, GA, April 12-13, 1984 (Abstract 1:3).

Obizoba, I. C. 1984. Comparative Nutritional Value of Legume Proteins Supplemented with Rice Fed Rats at Equal Intake. Ecology of Food and Nutrition 14:71-75.

Phillips, R. D, M. S. Chhinnan and L. G. Mendoza. 1983. Effect of Temperature and Moisture Content on the Kinetics of Trypsin Inhibitor Activity, Protein in vitro Digestibility and Nitrogen Solubility of Cowpea Flour. Journal of Food Science 48:1863-1867.

Phillips, R. D., M. S. Chhinnan and M. B. Kennedy. 1984. Effect of Feed Moisture and Barrel Temperature on Physical Properties of Cowpea Meal. Journal of Food Science 49:916-921.

Phillips, R. D. and G. P. Burch. 1984. Effects of Extrusion on Solubility and Electrophoretic Behavior of Cowpea Proteins. 75th Annual Meeting, American Oil Chemists' Society, Dallas, TX, April 29-May 3, 1984 (Abstract in Journal of American Oil Chemists' Society 61:682).

SENEGAL • UNIVERSITY OF CALIFORNIA, RIVERSIDE

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

I. PROJECT ROSTER

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

Principal Investigator:	Dr. A. E. Hall, Department of Botany and Plant Sciences, UCR
Co-Principal Investigators:	Dr. K. W. Foster,* Department of Agronomy and Range Science, University of California, Davis (UCD)
	Dr. P. N. Patel, Department of Botany and Plant Sciences, UCR
Cooperators:	Dr. W. M. Jarrell, Department of Soil and Environmental Sciences, UCR
	Dr. V. Marcarian,** Department of Plant Sciences, University of Arizona (UA)
Institutional Representative:	Dr. Lewis G. Weathers, College of Natural and Agricultural Sciences, UCR

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

Principal Investigator:***	Dr. Mbaye Ndoye, Head, Crop Production Department, ISRA
Coordinator:	Mr. Mamadou Ndiaye, Rhizobiologist, ISRA
Plant Breeder:	Mr. Ndiaga Cisse, Crop Production Department, ISRA
Adviser to US Team:	Mr. Samba Thiaw, Crop Production Department, ISRA
Plant Physiologist:	Mr. Thiaka Diouf, Crop Production Department, ISRA
Technicians:	Ms. Ndeye Salane Faye, Plant Physiologist, Crop Production Department, ISRA
	Mr. Assane Sene, Agronomist, Crop Production Department, ISRA
	Ms. Khady Diop, Entomologist, Crop Production Department, ISRA
Bioclimatologist:	Mr. Claude Dancette, Crop Production Department, ISRA

*Dr. Foster left UCD and the project on July 31, 1984.

**Dr. Marcarian is carrying out associated work on cowpea biological nitrogen fixation (BNF) at the University of Arizona.

***Dr. Ndoye replaced Dr. M. Mbodj as Principal Investigator (PI) on September 1, 1983.

Cooperators: Dr. Dogo Seck, Department of Crop Storage, ISRA
Mr. Mankeur Fall, Department of Cropping Systems, ISRA
Mr. Moustapha Diop, Head, Louga Sub-Station, ISRA

C. USAID Project Officer: Mr. John Balis, Agricultural Development Officer, USAID/Dakar

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives: The long-term goal is to develop cowpea production systems that have increased grain production and yield stability for subsistence farmers in hot, semiarid zones. The objectives for the first five years are to:

1. Develop improved cowpea cultivars and management methods for the semiarid zone of Senegal.

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

3. Develop germplasm and methodologies for improving cowpea production in hot, semiarid zones throughout the world.

B. FY 84 Objectives: Starting with the first harvests in the fourth cropping season (early September 1984), some emphasis will be given to obtaining useful baseline data and applied research on the storage and marketing of cowpeas in the semarid zone of Senegal.

III. CHANGE IN FY 84 OBJECTIVES

The preliminary village-level studies of cowpea storage and marketing were added because damage by cowpea weevil is probably a major constraint to achieving the long-term goal of increased production and utilization. These additional studies are consistent with the general recommendations of the CRSP Management Office that baseline information be obtained concerning current village-level activities and constraints.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. Just prior to the beginning of the fourth year (September 1, 1983), the organizational structure of agricultural research in Senegal was substantially altered, due partially to the negotiation of loans and grants between the Government of Senegal and certain international agencies. This necessitated a change in Host Country Principal Investigator with Dr. Mbaye Ndoye, who became the Director of the new Department of Crop Production of ISRA, replacing Dr. Mahawa Mbodj. Dr. Ndoye was already an active member of the ISRA/CRSP cowpea research team so no harm to the progress of the project resulted. However, the change in organizational structure required alterations in the system for administering funds. Fiscal reports were provided for the period ending September 31, 1983 and the Government of Senegal has established a new and appropriate system for administering the project funds. Unfortunately, this change

took considerable time, and fiscal reporting by ISRA to UCR was delayed. Consequently, ISRA is only now being reimbursed for expenditures incurred after October 1, 1983. The planned project activities in Senegal have continued. It is likely, however, that the Government of Senegal has been paying a higher proportion of project costs than was estimated when earlier budgets were prepared, and this is leading to an imbalance between Host Country (HC) and US expenses.

B. Dr. K. W. Foster, the Co-PI from UCD, resigned from the University, effective July 31, 1984. This was most unfortunate because of the excellent contribution his cowpea breeding work was making to this CRSP and to the cowpea farmers of California. The US PI, Dr. A. E. Hall, has initiated the steps necessary to enable the two CRSP-funded graduate students who had been supervised by Dr. Foster, Mr. Jeff Ehlers and Ms. Katie Rigert, to complete their Ph.D. programs at UCD; to transfer the cowpea germplasm with improved canopy architecture developed by Dr. Foster for the CRSP to the UCR-CRSP project; and to continue the cowpea breeding for improved canopy architecture at UCR. Consideration will be given to future cooperation between UCR and UCD when personnel have been identified at UCD who can contribute to the Senegal/UCR project.

V. PROGRESS TOWARD OBJECTIVES

A. Objective 1--Development of Improved Cultivars and Management Methods for Senegal

1. Rainfall during the 1983 cropping season (which ended at the beginning of the fourth year of the project) was the lowest recorded during the last 66 years in semiarid Senegal. Varietal tests in this year and earlier seasons, which were also dry, have demonstrated that the stability of farming in the drier part of the semiarid zone could be improved if farmers were to grow specific local cowpeas together with some of the early erect cowpeas developed at UCR and UCD. On-farm tests are being conducted in Senegal during the 1984 cropping season to evaluate the cowpeas developed by the project under farm conditions and to obtain feedback concerning their acceptability to farmers and consumers.

2. Studies conducted of different intercropping and solecropping systems have not shown consistent, significant differences due to the variability caused by the harsh, dry conditions. Varietal intercrops are being evaluated which combine early, erect cowpeas with the more prostrate local ones. It is likely that the new, early, erect cowpeas should be sown at higher plant densities than is presently practiced with the prostrate local varieties. Sufficient information is now available concerning cowpea management to conduct sensible on-farm tests of the new cowpea varieties.

B. Objective 2--Training and Technical Assistance

1. The ISRA plant breeder received technical advice by working with Dr. K. Foster in Senegal on germplasm collection, by working

with Dr. P. N. Patel in choosing heat-tolerant germplasm for Senegal at UCR during the project's annual meeting and by attending the MSTAT workshop on the use of computers in plant breeding at MSU.

2. The ISRA rhizobiologist received technical advice by working with Dr. W. Jarrell in Senegal and Dr. A. E. Hall and Mr. H. Elowad at UCR on ureide measurements as a rapid screening method for BNF.

3. The ISRA agronomist is making good progress in studies for his B.S. degree at UCR.

C. Objective 3--Developing Germplasm for Semiarid Zones: Screening techniques for improved heat tolerance and drought adaptation are being applied in a breeding program at UCR, and additional potentially useful cowpea lines have been supplied to ISRA, the Bean/Cowpea CRSP project in Botswana, the AID-funded Western Sudan Agricultural Research Project and several other cowpea projects in developing countries.

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use

1. Cowpea lines are now available at UCR with heat tolerance, which are moderately early, day neutral and erect and have adequate seed quality. Some of these lines should be more suitable for West Africa (Senegal local cowpeas were used in the crosses), whereas others may perform better in environments where night temperatures are intermediate between California and West Africa (e.g., Botswana and East Africa) because California Blackeyes were used as parents. ISRA and other cooperators are being provided with these lines and will evaluate their agronomic characteristics and select ones which suit their local conditions.

2. Cowpea strains from cooperators have been screened at UCR. The herbicide screen indicates that Bambey 21, Grant, Cross 1-6E-2, Quarenta Dias, Reata, CNCX 27-2E, Pittiuba and TVx 3236 probably have more extensive root systems than Vita 1, TVx 1836-015J, 4R-0269-1F, TVx 309-1G, 8006 and TVx 133-16D-2. Other strains screened were intermediate. Strains were identified at UCR which probably have early flowering under a broad range of environmental conditions: 7964, UCR 187, UCR 192, UCR 193, UCR 194, UCR 207, Cross 1-6E-1, TKx 133-16O-1, Rawal 4-1 and IT82E-18.

3. A rapid screen for BNF by cowpeas under dryland conditions was developed at UCR. Concentration of ureides in stem tissue (obtained by hot water extracts) was well correlated with rates of acetylene reduction and concentration of ureides in xylem sap in greenhouse and field conditions. Measuring ureides in stem tissue offers considerable promise for screening cowpea lines for BNF under field conditions. ISRA scientists have been screening local and UC cowpeas for BNF activity in the field using the acetylene reduction method, but they consider that it

is too time-consuming and possibly too unreliable due to the uncertainty involved in digging up root systems. The ureide method, based upon hot water extracts from stem tissue, could help them and other cowpea breeders to make more rapid progress in screening cowpea lines. Insuring that cowpea varieties have adequate BNF is important for the semiarid zone of Senegal because the soil has low fertility and there is little possibility for using nitrogen fertilizer on the millet-cowpea fields in the near future.

4. Scientists at UCD have developed cowpea genotypes with different canopy characteristics. Information concerning the inheritance of these characters should facilitate the breeding of "bush"-type cowpeas with improved canopy architecture.

B. Available for Use Within One to Two Years: Varietal tests conducted by ISRA scentists over three years have shown that the following early, erect cowpea strains, developed by the project, could improve the stability of cowpea production in the drier part of the semiarid zone in Senegal: 1-2-1, 1-8-5, 1-11-1, 1-12-3, 3-4-1, 3-4-11, 3-4-13 and 8047. This is the case provided that farmers also sow a proportion of their land to the local, later and more prostrate cowpea, 58-57, which these tests indicate has broad adaptability. The higher yielding, early, erect cowpeas produced 500 to 1000 kg/ha of dry grain in Louga, Senegal in two years when rainfall was only 135 and 180 mm. The best strains from Senegal and UC also produced four times more yield than the best local Sudanese cowpeas in an extremely dry location in the Sudan in 1983. On-farm tests of these varieties, presently under way in Senegal during the fourth year, will initiate the process of extending them to farmers.

VII. TRAINING OUTPUTS

The degree and non-degree training of students and scientists from Senegal, the Sudan and the US is carefully integrated with the research projects conducted for the CRSP at the University of California. The US research component of the project is providing excellent training opportunities for international and US students.

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
Robertson	F	UCR	Plant Sci.	Ph.D.	Fall 84	Partial
Ehlers	M	UCD	Agronomy	Ph.D.	Fall 84	Total
Mutters	M	UCR	Plant Sci.	Ph.D.		Partial
Nielsen	F	UCR	Plant Sci.	M.S.	12/83	Partial
Rigert	F	UCD	Agronomy	Ph.D.		Partial
Senegal Citizens:						
Thiaw	M	UCR	Plant Sci.	B.S.		Total
Diop	F	UCR	Entomology	B.S.		Total

Others:						
Elowad	M	UCR	Plant Sci.	Ph.D.	Fall 84	Partial
El Madina	M	UCR	Plant Sci.	M.S.		Partial
Mohamed	M	UA	Plant Sci.	Ph.D.	80	Partial
Tewolde	M	UA	Plant Sci.	M.S.	5/84	Partial
Abbas	M	UA	Plant Sci.	M.S.	12/84	Partial

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
None					
Senegal Citizens:					
Cisse	M	ISRA	MSTAT	MSU	One week
Thiaw	M	ISRA	English	UCR	Ten weeks
Ndiaye	M	ISRA	Ureides as a measure of BNF in cowpeas	UCR	Three weeks
Others:					
None					

VIII. BASELINE DATA

Village-level studies of cowpea storage and marketing could make an important contribution to the long-term goal of increasing cowpea production and utilization. Unfortunately, the cooperating ISRA scientists were only to initiate the on-farm studies of cowpea storage in the 1983-84 storage season. They intend to expand the village-level studies of cowpea storage and marketing during the 1984-85 storage season.

IX. WOMEN IN DEVELOPMENT

This project has attracted US students who were seeking opportunities to conduct relevant field research, and three of the five students receiving support from the project for their studies are women. Ms. Khady Diop of the ISRA cowpea team commenced English and degree studies at UCR starting at the end of the fourth year.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO THE PROJECT

A. United States

1. Personnel

Dr. A. E. Hall, professor, 20 percent.
Dr. K. W. Foster, assistant professor, 15 percent up to 7/31/84.
Dr. W. M. Jarrell, associate professor, 10 percent.
Mr. A. N. Eckard, staff research associate, 10 percent.
Mr. R. Demoura, staff research associate, 10 percent.
Ms. D. J. Franke, management services officer, 5 percent.
Approximate dollar value: $22,000

2. Student training: This has involved partial support from UC to four US students.

3. Facilities: The following resources were used by the project at UCR and UCD in 1983-84:

   a. Research laboratories, five, totaling 2000 square feet
   b. Offices, four, totaling 400 to 500 square feet
   c. Greenhouses, three, totaling 4000 square feet
   d. Experimental fields at UCD, six acres; UCR, eight acres; and the UC field station in Imperial Valley, four acres
   e. Numerous items of equipment

B. Senegal

1. Personnel: The twelve people listed on the Senegalese personnel roster are paid by the Senegal government and are contributing a major proportion of their time to the CRSP project. In addition, there are several technicians and a driver working for the project who are paid by the government.

2. Facilities:

   a. Senegal provides five offices and five laboratories at the Centre National de Recherches Agronomiques (CNRA), Bambey for use by this project.

   b. The research uses twenty-five acres of the large experimental farms at Bambey and Louga each year.

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages

1. Germplasm was supplied to the Bean/Cowpea CRSP project in Botswana, and an excellent meeting was held at UCR with Drs. deMooy and Burke and Ms. B. deMooy to plan future cooperation.

2. Germplasm was supplied to the Halima, Agricultural Research Station, Wau, Sudan and to Paraguay (at the request of USAID, Washington).

3. The US PI visited the cowpea breeding program in Mali and arranged for the Malian cowpea breeder to visit the CRSP cowpea team in Senegal.

4. Informal cooperation in the exchange of germplasm of vegetable-type cowpeas was established with the University of the West Indies.

B. On-Going Linkages

1. Three members of the CRSP cowpea team in Senegal visited IITA, Ibadan, and a technician from the team took a course there. The Senegal cowpea team has been conducting varietal trials

with cowpeas from both the CRSP and IITA. Dr. Earl Watt, from IITA, Brazil, visited the UCR and UCD projects to discuss breeding strategies and arrange further exchanges of germplasm.

2. The project has provided additional germplasm to the USAID-funded Western Sudan Agricultural Research Project, and at their request, Dr. A. E. Hall visited to provide technical assistance in September and October 1984.

3. The cowpea growers of California continued to support the research of Drs. A. E. Hall and K. W. Foster, which is also directed toward the development of new varieties for California.

XII. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy

1. US research will be conducted mainly at UCR. Plans are to:

   a. Continue the development of heat-tolerant cowpeas, in different genetic backgrounds, for cooperators in tropical countries and evaluate their agronomic value.

   b. Investigate the various reproductive processes which are damaged by heat and the inheritance of heat tolerance using different genetic sources.

   c. Investigate the extent to which genes conferring heat tolerance at flowering also result in modifications to other plant properties and influence the breadth of cowpea adaptation to different thermal regimes.

   d. Investigate the expression and inheritance of early flowering in day-neutral cowpeas under different thermal regimes.

   e. Evaluate cowpeas selected for differences in rooting (using the herbicide screen) and earliness to determine whether selection has resulted in useful increases in drought resistance.

   f. Test a possible new technique for screening for differences in integrated, intrinsic water-use-efficiency. This technique is based upon delta C^{13} discrimination, and the assays will be made by Dr. G. Farquhar of the Australian National University (at no cost to the project). Selection for increases in water-use efficiency should increase drought resistance.

   g. Continue the development of cowpeas with improved canopy architecture using the germplasm and information concerning character inheritance developed by Dr. K. Foster at UCD.

   h. Continue the studies of inheritance of resistance to fusarium wilt in cowpeas (Ph.D. studies of Ms. Katie Rigert

at UCD) and incorporate resistance to fusarium wilt into some of the heat-tolerant cowpea germplasm being developed for the tropics (to be conducted at UCR).

i. Investigate the potential value of the UCR vegetable-type cowpeas for use in the tropics.

2. Research in Senegal

a. Breeding: Continue varietal trials at Bambey and Louga and the on-farm testing of ISRA, UCR and IITA cowpeas. Continue evaluation and selection of heat-tolerant and early germplasm supplied by UCR. Continue the breeding program to develop cowpeas for Senegal with resistance to drought, through emphasis on earliness, high harvest index and resistance to insects.

b. Rhizobiology: Evaluate the extent of nodulation and nitrogen fixation by cowpeas in different farm conditions. Use acetylene reduction and ureide methods to continue to screen different cowpea strains on experimental station fields and cooperate with the breeder to insure that new cultivars have high BNF.

c. Physiology and agronomy: Evaluate the extent to which soil nutrients, such as phosphorus and possibly micronutrients, limit cowpea yield and BNF. Conduct studies to develop improved fertilization practices using locally available materials, such as rock phosphates. Determine optimal plant densities for different types of cowpeas in different production zones and the extent of rooting and water extraction in relation to the hydrologic balance. Continue studies to determine the extent of flower abscission due to environmental factors and insects in different cowpea genotypes.

d. Entomology: Evaluate methods for controlling Amsacta moloneyi in the Louga region, such as applications of the biological control agent Bacillus thuringiensis. Continue to evaluate the damage caused by thrips to different cowpea strains having different levels of resistance at the more humid location, Nioro du Rip, where natural levels of thrips are usually high.

e. Bioclimatology: Continue the evaluation of different cowpea cropping systems under experiment station and on-farm conditions.

f. Storage and marketing: Conduct surveys of cowpea storage methods and marketing in the Louga and Thies regions and conduct on-farm tests of improved cowpea storage methods.

g. Synthesize available baseline information concerning cowpea production and utilization in Senegal.

B. Training Objectives and Strategy

1. United States: Ms. B. Robertson, Mr. J. Ehlers and Ms. C. Nielsen have essentially completed their graduate programs. Ms. K. Rigert is continuing her research on resistance to fusarium wilt at UCD. Mr. R. Mutters has just begun research on the physiology and genetics of cowpea response to heat at UCR, and his studies will complement the present breeding program.

2. Senegal: The training of Mr. S. Thiaw toward a degree in agronomy will continue, and the training of Ms. Khady Diop toward a degree in entomology will begin at UCR. Mr. H. Elowad will soon return to the USAID-funded WSARP in the Sudan, and Mr. I. Dow El Madina should complete his M.S. during the fifth year of the project at UCR and then return to WSARP. At the beginning of the fifth year, it is anticipated that Mr. Moses Kwapata from Malawi will return to UCR under Semiarid Food Grain Research and Development Project funds to study for a Ph.D. while conducting research on vegetable-type cowpeas.

C. Anticipated Personnel/Locational Changes: After completing his Ph.D. at UCD (under the supervision of Dr. Foster) Mr. Jeff Ehlers will come to UCR on a post-doctoral appointment for one year. One of his tasks would be to insure that the germplasm and concepts developed by the Foster-Ehlers project on canopy architecture are integrated into the UCR breeding project and are not lost due to the resignation of Dr. Foster from the university.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Cisse, N., Thiaw, S. and A. Sene. 1984. Project CRSP Niébé Essais Variétaux 1983. Bambey, Senegal: Centre National de Recherches Agronomiques.

Dancette, C. 1984. Principaux Résultats Obtenus en 1983 par la Division de Bioclimatologie sur les Systemes de Culture a Base de Niébé au Sénégal. Bambey, Senegal: Centre National de Recherches Agronomiques.

Diouf, T. 1984. Physiologie du Niébé--Facteurs Climatiques--Croissance et Développement du Niébé. Bambey, Senegal: Centre National de Recherches Agronomiques.

Ehlers, J. D. 1984. Assessment and Utilization of Exotic Cowpea Germplasm to Improve Black-Eyed Pea, Vigna unguiculata (L) Walp. Ph.D. Dissertation, University of California, Davis.

Ehlers, J. D. and K. W. Foster. 1984. Evaluation of Two Exotic Cowpea Introductions at Three Levels of Introgression for Six Agronomic Characters. Manuscript. Davis, CA: University of California at Davis, Department of Agronomy and Range Science.

_____. 1984. Inheritance of Growth Habit in Crosses Among Vining-Indeterminate, Non-Vining Indeterminate and Determinate Cowpea Lines. Manuscript. Davis, CA: University of California at Davis, Department of Agronomy and Range Science.

_____. 1984. Quantitative Inheritance of Five Agronomic Traits in Adapted x Exotic Crosses of Cowpea. Manuscript. Davis, CA: University of California at Davis, Department of Agronomy and Range Science.

Hall, A. E. 1984. Developing Cowpea Varieties with Improved Yield under Conditions of Extreme Drought and Heat. Research Highlights I(1). East Lansing, MI: Michigan State University, Bean/Cowpea CRSP Management Office.

Ndiaye, M. 1984. Etude de la Nodulation et de la Fixation d'Azote de 10 Varieties de Niébé en Symbiose Avec les Souches de Rhizobium Locales. Bambey, Senegal: Centre National de Recherches Agronomiques.

Ndoye, M. and K. Diop. 1984. Principaux Résultats Entomologiques Obtenus dans la Cadre du Project CRSP--Niébé au Senegal en 1983. Bambey, Senegal: Centre National de Recherches Agronomiques.

Nielsen, C. L. and A. E. Hall. In press. Responses of Cowpea (Vigna unguiculata (L.) Walp.) in the Field to High Night Air Temperature During Flowering. I. Thermal Regimes of Production Regimes and Field Experimental System. Field Crops Research.

_____. In press. Responses of Cowpea (Vigna unguiculata (L.) Walp.) in the Field to High Night Air Temperature During Flowering. II. Plant Responses. Field Crops Research.

Shackel, K. A. and A. E. Hall. 1984. Effect of Intercropping on the Water Relation of Sorghum and Cowpea. Field Crops Research 8:381-387.

TANZANIA • WASHINGTON STATE UNIVERSITY

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-Principal Investigator:	Dr. J. M. Due, Department of Agricultural Economics, University of Illinois (UI)
Virologist:	Dr. G. I. Mink, Department of Plant Pathology, IAREC, WSU
Nutrition Advisors:	Dr. H. H. Koehler, Department of Food Science and Human Nutrition, WSU
	Dr. B. G. Swanson, Department of Food Science and Human Nutrition, WSU
Economist:	Dr T. Schotsko, Department of Agricultural Economics, WSU
Research Technician:	Ms. L. J. Mills, IAREC, WSU
Greenhouse Attendant:	Ms. L. Potter, IAREC, WSU
Mechanical Engineer:	Dr. Dennis Davis, Department of Agricultural Economics, WSU
Administrator:	Dr. D. L. Oldenstadt, Associate Director, College of Agriculture, WSU
Finance Officers:	Mr. Vincent Hutnak, Controller, WSU
	Mr. J. J. Kramer, Office of Business Affairs, UI
Institutional Representative:	Dr. L. L. Boyd, Director, Agricultural Research Center, WSU

B. Tanzania Counterpart Institution: Sokoine University of Agriculture (SUA)*

Principal Investigator:	Prof. B. J. Ndunguru, Bean Project Leader, SUA
Plant Pathologists:	Prof. C. L. Keswani, Department of Crop Science, SUA
	Dr. M. T. Mbaga, Department of Botany, University of Dar es Salaam
	Dr. J. M. Teri, Department of Crop Science, SUA

*During 1984, the Faculty of Agriculture, Forestry and Veterinary Science, University of Dar es Salaam, Morogoro was upgraded to a fully-fledged university known as Sokoine University of Agriculture.

Plant Breeders:	Prof. B. S. Gill, Department of Crop Science, SUA
	Dr. A. L. Doto, Department of Crop Science, SUA
	Mr. R. N. Misangu, Department of Crop Science, SUA
Agricultural Engineer:	Dr. Mrema, Department of Agricultural Engineering, SUA
Food Scientist:	Dr. Maeda, Department of Food Science, SUA
Entomologists:	Prof. A. K. Karel, Department of Crop Science, SUA
	Ms. Martha Quentin,* Department of Crop Science, SUA
Weed Scientist:	Dr. A. N. Minjas, Head, Department of Crop Science, SUA
Plant Physiologist:	Dr. A. J. Tesha, Department of Botany, University of Dar es Salaam
Lecturer:	Mr. A. J. P. Tarimo, Department of Crop Science, SUA
Soil Scientist:	Dr. J. M. R. Semoka, Department of Soil Science, SUA
Microbiologist:	Dr. M. P. Salema, Department of Soil Science, SUA
Agricultural Economist:	Dr. Mlay, Department of Rural Economy, SUA
	Mr. E. Mbiha, Department of Rural Economy, SUA
Tutorial Assistant:	Ms. Winfreda P. Rwamugira, Department of Crop Science, SUA
	Mr. R. B. Mabagala, Department of Crop Science, SUA
Institutional Representative:	Deputy Vice Chancellor M. L. Kyomo, Department of Crop Science, SUA

C. USAID Project Officer: Mr. Ken Lyvers, Agricultural Development Officer, USAID/Dar es Salaam

II. PROJECT OBJECTIVES

A. Overall (Five Year) Objectives

1. Develop high-yielding disease and insect resistant cultivars (cvs) of beans for the smallholder family.

2. Assess the economic impact of new cvs and/or production or storage practices on smallholder farm families, especially on women's roles in the production, consumption and marketing process.

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*Ms. Quentin entered a Ph.D. program at Michigan State University fall term 1984.

B. FY 84 Objectives: Continue toward five-year objectives but include studies on drought stress and nutritional improvement. These additions were approved by the Bean/Cowpea CRSP Board of Directors (BOD) September 20, 1983.

III. CHANGE IN FY 84 OBJECTIVES: None.

IV. CONSTRAINTS TO ACHIEVEMENT OF OBJECTIVES

A. At the University of Dar es Salaam, Dr. Tesha was ill much of the year.

B. At SUA, transport was a major limitation due to gas shortages and equipment breakdowns. Dr. Seenappa, food scientist, and Dr. Manday, agricultural economist, left SUA, so little progress was made in those areas except for publication of previous research results. Delay of equipment purchase clearance by AID/Washington continues to be a serious problem.

V. PROGRESS TOWARD OBJECTIVES

Progress was achieved in four main areas: crop improvement (breeding and selection), crop protection (entomology, plant pathology and weed control), crop production (agronomy, physiology and biological nitrogen fixation [BNF]) and socio-economics (production economics, labor, food supply and women in development [WID]).

A. Crop Improvement

1. The Tanzanian cv TMO-101 and the Ugandan cv Kabanima are superior at low and high elevations, respectively, and are being increased for on-farm testing (OFT).

2. Hybridization of elite parent lines from worldwide sources continues at Morogoro, Prosser and CIAT to combine multiple factors for disease resistance with desirable plant and seed characteristics. Some F_5 lines are in observation and selection trials continue at several locations in Tanzania, Colombia and the state of Washington. New hybrids at Morogoro and CIAT will introduce insect resistance into the best F_5 multiple disease resistant materials and the best local landraces.

B. Crop Protection

1. Hybrid populations and breeding lines were screened for disease and insect resistance at Morogoro, Prosser and CIAT. Some lines now have combined resistance to bean common mosaic virus (BCMV) and halo blight (HB) (Prosser); some have BCMV, angular leaf spot (ALS) and rust (Morogoro) resistance; and some have BCMV, rust, mildew and anthracnose (CIAT) resistance. Parent lines with resistance to bean fly, Ootheca, bruchids and stem borer have been identified. The economic importance of BCMV, ALS and rust ranged between 24 and 74 percent. Since small farmers in

Tanzania cannot purchase pesticides to control these diseases, the value of genetic resistance becomes apparent.

2. Weeding is most effective three to four weeks after planting.

3. Vegetable oils protect stored beans against insects, and neem oil appears useful against field insects. Neem is easily grown, and extraction methods are simple and inexpensive.

4. A preliminary bean virus survey in Tanzania indicates there are at least five or six different virus diseases present besides BCMV.

5. Greenhouse trials at Prosser are in progress to develop a set of halo blight differential cvs and a screening technique to identify combined resistance to necrotic BCMV and HB.

6. Growing beans in mixtures reduces the incidence of rust and ALS and increases yields.

7. Parents and F_3 hybrids were screened for heat tolerance in several US locations. Screening methodologies are being refined for large-scale testing. Several promising materials were identified.

8. Over 600 hybridoma cell lines which produce monoclonal antibodies (MCAB) to BCMV were developed. One broad spectrum MCAB line is being tested internationally to verify its usefulness. A serological diagnostic kit will be developed for rapid virus identification. A simple technique for detecting seedborne BCMV has been developed using nitrocellulose membrane and monoclonal antibody.

C. Crop Production: Lack of water is the most important factor influencing production. Studies indicate that time of planting, mulching, cultivars, fertilizers, BNF, nutrient uptake and partitioning seem to be most directly affected by available moisture. Since moisture is often limited, the need for drought tolerance and high temperature stress tolerance was emphasized. Most cvs responded to BNF. Indigenous strains with high BNF capabilities will be screened for compatibility with the best cvs.

D. Socio-Economic Studies

1. In 1980, non-mechanized farm families in Kilosa District obtained 91 percent of total caloric needs from four major crops, of which beans contributed 6 percent. Based on grams of utilizable protein, families received 108 percent of their grams of utilizable protein needs; and beans provided 19 percent. Linear programming model analysis showed the main family production concern is food supply (calories and protein).

2. In 1982, in Arusha region, 98 percent of farm families grew beans (22 percent of average 3.1 ha/family farm). Most acreage

is intercropped, and most farmers grow beans with maize. Beans provided 20 percent of the gross value of crops produced and 13 percent of sale income. Families consumed 62 percent of beans grown, sold 35 percent and lost 3 percent. Data were obtained on cv yield, palatibility, storage, sales and favorite recipes and on responses to suggested changes in bean yields and prices. This information will be used by breeders to establish acceptability criteria for cv development.

VI. RESEARCH OUTPUTS DURING FY 84

A. Available for Immediate Use

1. Ready for immediate OFT are the cvs TMO-101 and Kabanima, oils to reduce bruchid damage in seed storage, cv mixtures in the field to reduce disease injury and information on early planting and timely weeding.

2. A greenhouse method for dual screening of BCMV and HB is ready for general use by other Bean/Cowpea CRSP breeders.

B. Available for Use Within One to Two Years

1. The enzyme-linked immunosorbent assay (ELISA) serology kit for rapid BCMV virus identification should be ready for use in one or two years, as should the use of home-grown neem oil to control insect pests.

2. Several hybrid lines with multiple disease resistance will be ready for OFT in about two years.

3. Germplasm and methodology for high temperature tolerance during bloom will be available to other bean breeders in approximately two years. The use of MCAB to assay for seedborne BCMV should be ready for general use in two years.

VII. TRAINING OUTPUTS

A. Degree Training

Surname	Sex	University	Department	Degree	Date Degree Received	CRSP Support
US Citizens:						
Gillard-Byers	M	UI	Ag. Econ.	Ph.D.	May 1984	Partial
Rocke	M	UI	Ag. Econ.	MS		Total
Tanzania Citizens:						
Rugambisa	M	UI	Ag. Econ.	Ph.D.		Total
Nchimbi	F	UW	Horticulture	M.S.		Total
Mollel	M	UI	Ag. Exten.	M.S.		Total
Quentin	F	MSU	Entomology	Ph.D.		Total
Others:						
Wang	M	WSU	Plant Path.	Ph.D.		Total

B. Non-Degree Training

Surname	Sex	Affiliation	Training	Location	Duration
US Citizens:					
Doyle	M	WSU	MSTAT Wkshp.	MSU	One week
Boge	M	WSU	MSTAT Wkshp.	MSU	One week
Rocke	M	UI	MSTAT Wkshp.	MSU	One week
Tanzania Citizens:					
Nchimbi	F	UW	MSTAT Wkshp.	MSU	One week
Misangu	M	SUA	MSTAT Wkshp.	MSU	One week
Mollel	M	UI	MSTAT Wkshp.	MSU	One week
Others:					
None					

The three Tanzanian and three US people who attended the MSTAT computer workshop thought it was very worthwhile. Dr. T. Gillard-Byers finished his Ph.D. in May 1984 and is in Sudan with a WSU/AID Project. Mr. J. Rugambisa expects to finish a Ph.D. in December 1984. He will return to Morogoro to work on bean marketing. Ms. Susan Nchimbi is almost finished with a M.S. She will continue toward a Ph.D. in plant breeding at the University of Wisconsin (UW). Mr. T. Rocke will do part of his M.S. degree work in Morogoro. Mr. Wei-Young Wang has finished course-work and preliminary examinations toward a Ph.D. in virology. Mr. Mabagala plans to begin at Michigan State University (MSU) in February, and Mr. Misangu intends to begin graduate work at the University of Nairobi sometime in 1985.

The Third Annual Bean Workshop was held at Morogoro, August 27-28. Approximately fifty people attended including personnel from other Bean/Cowpea CRSP projects, the External Review Panel, TARO and the Uyole Agricultural Research Center. Twenty-eight of those participating were students who were reporting on bean research experiments they had carried out under the direction of a faculty member as part of their senior class project.

VIII. BASELINE DATA

Baseline data on the smallholder farm family and the role of beans in the farming systems of various regions have been collected for three years. Some of these results were reported in sections V and IX. No new work was done in FY 84 because Dr. Manday left SUA.

IX. WOMEN IN DEVELOPMENT

Many women are involved in this project as researchers, technicians and students and women's roles in agricultural production receive considerable attention.

A. United States

Ms. Marcia White worked as a research technician for Dr. Due. Ms. Lynn Mills, research technician, and Ms. Lois Potter, greenhouse helper, worked for Dr. Silbernagel.

B. Tanzania

Ms. Susan Nchimbi is in training at UW, and Ms. Martha Quentin is at MSU, both working toward Ph.D. degrees. Only one out of about twenty undergraduates at SUA is a woman. Ms. Winfreda Rwamugira is contemplating graduate training sometime in the future. Women are well represented in both US and Tanzanian research.

On the smallholder farm level, women provide about 50 percent of the production labor, in addition to traditional household and child-care duties. Most decisions regarding which crops and/or seeds to plant are made jointly by husband and wife or by the wife alone. Women do most of the bean harvesting, storage, marketing and cooking. Women interviewers are needed for socio-economic surveys to assure that a proper assessment of women's acceptability criteria for new cvs is obtained. Information on new production practices or cvs must be made available to farm women, since they are more concerned with bean production and utilization than men.

X. INSTITUTIONAL RESOURCES CONTRIBUTED TO THE PROJECT

A. United States

1. University of Illinois

a. Personnel

Dr. J. M. Due, professor, 25 percent, $15,521.32
Mr. J. J. Kramer, finance officer

b. Facilities: Typing & Phone, $7,000.00

Total University of Illinois, $22,521.32

2. Washington State University

a. Personnel

Dr. M. J. Silbernagel, plant pathologist, 20 percent, Federal
Dr. G. I. Mink, professor, 15 percent, $7,275.00
Dr. H. H. Koehler, professor, 10 percent, $3,436.00
Dr. B. G. Swanson, professor, 10 percent, $3,536.00
Dr. D. L. Oldenstadt, administrator
Dr. L. L. Boyd, administrator, 5 percent, $3,101.00
Dr. V. Hutnak, finance officer
Dr. D. Davis, mechanical engineer
Dr. T. Schotsko, agricultural econo[illegible]

B. Tanzania--Sokoine University of Agriculture

1. Personnel

Prof. B. J. Ndunguru, associate professor, 25 percent, $928.57
Prof. C. L. Keswani, professor, 20 percent, $1,142.85
Prof. B. S. Gill, professor, 10 percent, $571.42
Prof. A. K. Karel, associate professor, 60 percent, $3,360.00
Dr. A. N. Minjas, senior lecturer, 10 percent, $354.28
Dr. A. L. Doto, senior lecturer, 10 percent, $354.28
Mr. R. N. Misangu, lecturer, 60 percent, $1,885.71
Ms. M.T. Mmbaga, senior lecturer, 25 percent, $885.71
Dr. J. M. Teri, senior lecturer, 20 percent, $708.56
Dr. J.M.R. Semoka, senior lecturer, 20 percent, $708.56
Mr. A.J.P. Tarimo, lecturer, 10 percent, $314.28
Ms. M. Quentin, assistant lecturer, 25 percent, $642.85
Dr. M.T.T. Mtoi, assistant lecturer, 10 percent, $314.28
Dr. M. P. Salema, lecturer, 15 percent, $471.42
Dr. A. J. Tesha, lecturer, 20 percent, $629.00
Ms. W.P. Rwamugira, tutorial assistant, 20 percent, $1,028.47
Mr. R. B. Mabagala, tutorial assistant, 20 percent, $1,028.47

Subtotal, $$8,971.79

2. Student training: Sixteen undergraduates in Tanzania, 10 percent of training cost, $7,314.28

3. Facilities

Research laboratories, 100 square feet, $1,000.00
Offices, 250 square feet, $2,500.00
Greenhouse , $1,000.00
Experimental fields (5 ha) @ 50$/ha, $250.00

Subtotal, $4,750.00

Indirect cost: Secretarial/paper/accounts/clerical, $3,000.00

Total, $24,035.87

XI. PROFESSIONAL AND ORGANIZATIONAL LINKAGES

A. New Linkages

1. United States: Dr. Jean Due visited CIAT to confer with agricultural economist and OFT specialists. She was also invited to visit CIAT programs in Keyna and Rwanda.

2. Tanzania: Dr. Eric Ayeh, Bunda College, Malawi, and Dr. Larry Lev, Oregon State University Farming Systems Project (OSU-FSP), Tanzania, attended the Third Annual Bean Workshop and gave presentations.

B. On-Going Linkages

1. United States

a. Dr. Silbernagel visited CIAT to review cooperative dry bean materials for East Africa and snap beans for the tropics. He visited bean researchers at the National Vegetable Research Station in Wellesbourne, England; the Institute for Horticultural Plant Breeding, Wageningen, Holland; and the National Institute for Agronomic Research, Versailles, France. At each location, he obtained information and germplasm useful to the bean program.

b. Dr. Due continues contributions to the Office of International Agriculture and the Office of Women in International Development at UI. She was appointed as a committee member by USAID/BIFAD to evaluate performance of strengthening grants to US Land Grant Universities. She spent ten days in Washington, DC.

2. Tanzania

a. Dr. Due continues linkages with university and government personnel in Tanzania and Zambia relative to non-CRSP-funded research on WID.

b. All project members continue close linkages with USAID/Dar es Salaam Mission agricultural officer, Mr. Ken Lyvers, through whom some PL-480 funds may be obtained for a bean field laboratory at Morogoro. AID/DAR also provides pouch mail access, Tanzanian team travel clearance and equipment import clearance. They are extremely cooperative and helpful in all matters.

c. Dr. Silbernagel maintains communications with the OSU-FS team in Corvallis and Dar es Salaam.

d. All team members maintain communications and collaborative research with bean workers at the Uyole Agricultural Centre, Mbeya; the Agricultural Research Institute, Lyamungu; the University of Dar es Salaam, Department of Botany; the Agricultural Research Institute, Maruku, Tanga and Ilonga; the Tanzanian Agricultural Research Organization, Dar es Salaam.

e. Tanzanian and US researchers are in contact with CIAT colleagues who visit Tanzania and the US to exchange information, germplasm, trial results and trip reports.

XII. FY 85 PROPOSED PLAN OF WORK

A. Research Objectives and Strategy: Within the context of the five-year objectives and amendments, as presented in section II.A and B, the following are the research priorities for FY 85.

1. United States

   a. Washington State University and the Irrigated Agricultural Research and Extension Center

      (1) Continue hybridization and screening to combine multiple disease resistance.

      (2) Publish data on dual screening for resistance to necrotic BCMV and HB.

      (3) Continue development of HB differentials.

      (4) Continue refinement of screening methods for identification of high temperature tolerance during bloom.

      (5) Publish information on the Tanzanian strain of BCMV.

      (6) Evaluate cooking time of parental lines.

      (7) Develop plans for a village thresher.

      (8) Complete work on verification of broad spectrum monoclonal antiserum for BCMV identification.

      (9) Initiate cloning and characterization of some of the 600 other hybridoma cell lines.

   b. University of Illinois

      (1) Dr. Due will help plan a socio-economic background study for Mbeya and a crop-intensive bean survey for Morogoro.

      (2) Mr. Mbiha will visit UI for consultation with Dr. Due and Mr. Rocke to help analyze data from FY 85 studies in Tanzania. Mr. Tim Rocke and Ms. Susan Rocke will work in Tanzania January-September 1985. He will focus on socio-economic studies, and she will carry out a nutrition evaluation of bean lines.

2. Tanzania--Morogoro

   a. Continue hybridization and screening for multiple disease and insect resistance.

   b. Share promising hybrid materials for evaluation with cooperators at Mbeya, Lyamungu, Maruku and Tanga.

   c. Continue agronomic studies on yield, maturity, BNF and drought tolerance.

   d. Initiate time-of-cooking evaluations.

   e. Conduct a virus survey and collect rhizobial strains from selected major bean areas.

f. Develop plans for a village thresher.

g. Conduct a bean acceptability criteria survey in the Morogoro region and a socio-economic background study in Mbeya.

h. Initiate on-farm testing trials in the Mgeta and Morogoro areas to: compare cvs TMO-101, Kabanima and Canadian Wonder; demonstrate use of vegetable oils at the farm household level to protect stored seed from bruchids; demonstrate benefits of organic composting and proper weed control.

i. Initiate a bean marketing study with emphasis on the contribution of beans to the economy and nutrition of smallholder households.

j. In all studies, continue to identify the role of women in crop production systems and their overall contributions to family subsistence.

B. Training Objectives and Strategy

1. United States

a. Washington State University: Mr. Wei-Young Wang will complete research toward the Ph.D. degree.

b. University of Illinois: Mr. Tim Rocke will do M.S. degree work at UI and thesis research at Morogoro.

2. Tanzania

a. Mr. J. Rugambisa will complete the Ph.D. (December 1984), return to Morogoro and begin bean marketing studies in collaboration with the WSU agricultural marketing specialist, Dr. Tom Schotsko.

b. Ms. Susan Nchimbi will complete M.S. requirements and continue training at UW toward the Ph.D. in plant breeding.

c. Mr. N. Mollel will continue studies at UI toward an M.S. in agricultural extension.

d. Ms. M. Quentin began work at MSU toward a Ph.D. degree in entomology.

e. Mr. R. Mabagala has been accepted for M.S. work in plant pathology at MSU, beginning in February 1985.

f. Mr. R. Misangu may begin Ph.D. studies at the University of Nairobi early in 1985.

g. Mr. A. Tarimo is applying for graduate school in the US.

C. Anticipated Personnel/Locational Changes

1. United States: Mr. Tim Rocke and Ms. Susan Rocke will work at SUA in Morogoro from January-September 1985.

2. Tanzania: None anticipated.

XIII. LIST OF ARTICLES AND PRESENTATIONS ON PROJECT RESEARCH DURING FY 84

Due, Jean M. and P. Anandajayasekeram. In press. Contrasting Farming Systems in Morogoro Region, Tanzania. Canadian Journal of African Studies.

Due, Jean M., P. Anandajayasekeram, Marcia White and Thomas E. Gillard-Byers. 1984. Beans in Two Contrasting Farming Systems in Morogoro Region, Tanzania, 1980. University of Dar es Salaam, Economic Research Bureau, No. 83.3.

Due, Jean M., P. Anandajayasekeram, N. S. Mdoe and Marcia White. 1984. Beans in the Farming Systems in Langali and Kibaoni Villages, Mgeta Area, Morogoro Region, Tanzania. University of Illinois, Department of Agricultural Economics, aAE-4560, February 1984. (Also available from University of Dar es Salaam, Department of Rural Economy, Technical Report No. 2.)

Due, Jean M., Emmanuel Manday, Marcia White and Timothy Rocke. 1984. Beans (Phaseolus vulgaris) in the Farming Systems in Arusha Region, Tanzania, 1982. University of Illinois, Department of Agricultural Economics, aAE-4567, August 1984. (Also available from University of Dar es Salaam, Department of Rural Economy, Technical Report No. 3.)

Gillard-Byers, Thomas E. 1984. The Allocation of Resources in the Non-Mechanized Small Farm Household of Dumula, Mkundi and Magole Villages and the Kilosa District, Tanzania: A Nutrition Based Approach. Ph.D. Dissertation, University of Illinois at Champaign-Urbana.

Karel, A. K. and C. L. Rweyemamu. 1984. Yield Losses in Field Beans Following Damage by Ootheca bennigseni (Coleoptra: Chrysomelidae). Journal of Economic Entomology 77:762-765.

Silbernagel, M. J. 1984. New Bean Technology for Detection and Identification of International Seed Borne Viruses. Research Highlights I(5). East Lansing, MI: Michigan State University, Bean/Cowpea CRSP Management Office.

Silbernagel, M. J., L. J. Mills and Wei-Young Wang. 1984. Tanzanian Strain (T-1) of Bean Common Mosaic Virus. Paper presented at the Annual Meeting Pacific Division American Phytopathological Society, Pasco, WA (Abstract in Phytopathology 79:1141).

Teri, J. M. In press. Yield Losses in Phaeolus Beans Induced by Anthracnose in Tanzania. Tropical Pest Management.

TABLE OF ACRONYMS

ALS	Angular Leaf Spot
AR	Acetylene Reduction
ARC	Agricultural Research Center
ARS	Agriculture Research Station
ATIP	Agricultural Technology Improvement Project
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
BTI	Boyce Thompson Institute
CARDI	Carribbean Agricultural and Development Institute
CATIE	Centro Agrónomico Tropical de Investigación y Enseñanza (Tropical Agricultural Center for Investigation and Teaching)
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)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
CNPAF	Centro Nacional de Pesquisa de Arroz e Feijão (National Center of Investigation for Rice and Beans)
CNRA	Centre National de Recherches Agronomiques
Co-PI	Co-Principal Investigator
CPES	Coastal Plain Experiment Station
CRSP	Collaborative Research Support Program
CSU	Colorado State University
CU	Cornell University
CPMV	Cowpea Mosaic Virus
cv(s)	cultivar(s)
D	Water Withheld
DAFS	Department of Agricultural Field Services (Botswana Extension Service)
DAR	Department of Agricultural Research (Ministry of Agriculture, Botswana)
DCAA	División de Ciencias Agrícolas y de Alimentos (Division of Agriculture and Food Science)
DR	Dominican Republic
EAP	Escuela Agrícola Panamericana (Pan-American Agricultural School)
EFSAIP	Evaluation of Farming Systems and Agricultural Implements Project
ELISA	Enzyme-Linked Immunosorbent Assay
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Enterprise for Agricultural Investigations)
ERP	External Review Panel
F	Flowering
FY	Fiscal Year
GERDAT	Groupment d'Etudes et de Recherché pour le Développement de l'Agronomie Tropicala (Association for Studies and Research for the Development of Tropical Agronomy)
GI	Gastro-Intestinal
GLIP	Grain Legume Improvement Program
GOB	Government of Botswana
HB	Halo Blight
HC	Host Country
IARC	International Agricultural Research Centers
IAREC	Irrigated Agricultural Research and Extension Center
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)
IPRC	Insect Pathology Resource Center
IR	Institutional Representative
IRA	Institut de la Recherché Agronomique (Institute of Agronomic Research)
ISRA	Institut Sénègalais de Recherches Agricoles (Senegalese Institute Agricultural Research)
KSU	Kansas State University
LPF	Late Pod Fill
MCAB	Monoclonal Antibodies
MDT	Mahalapye Development Trust
ME	Management Entity
MIRCEN	Microbiological Resource Centers
MNR	Ministry of Natural Resources
MO	Management Office
MOA	Ministry of Agriculture
MPF	Mid Pod Fill
MPN	Most Probable Number
MSTAT	Microcomputer Statistical and Data Management Package
MSU	Michigan State University
N	Normal Watering
NCRE	National Cereals Research and Extension Project
OFT	On-Farm Testing
OSU-FSP	Oregon State University-Farming Systems Project
PCCMCA	Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios (Central American Cooperative Program for the Improvement of Food Crops)
PCDA	Principal Components Distance Analysis
PER	Protein Efficiency Ratio
PI	Principal Investigator
PIP	Programa de Investigaciones de Produccion (Program for Production Investigations)
PM	Physiological Maturity
SAFGRAD	Semiarid Food Grain Research and Development Project
SEA	Secretaría de Estado de Agricultura (Secretary of State for Agriculture)
SEMRY	Société d Expansion et de Modernisation de la Riziculture de Yagoua (Rice production cooperative in Cameroon)
SODECOTON	Société de Développement du Coton (Cotton production cooperative in Cameroon)
SUA	Sokoine University of Agriculture
TARS	Tropical Agriculture Research Station
TC	Technical Committee
UA	University of Arizona
UCD	University of California, Davis
UCR	University of California, Riverside
UGA	University of Georgia
UI	University of Illinois
UM	University of Minnesota
UNE	University of Nebraska
UNK	University of Nairobi, Kenya
UPEU	Universidad Pedro Enriquez Urena
UPR	University of Puerto Rico
USAID	US Agency for International Development
USDA	US Department of Agriculture
UW	University of Wisconsin
UWI	University of the West Indies
VICAR	Central American Yield Nurseries
WID	Women-in-Development
WSARP	Western Sudan Agricultural Research Project
WSU	Washington State University