

10 Years of Collaborative Research
on Beans and Cowpeas



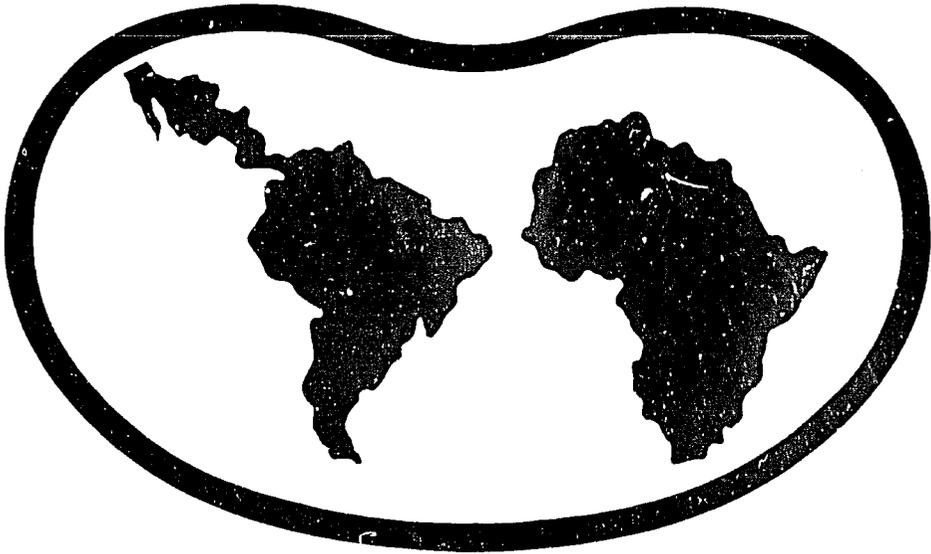
Foundation for the Future



Bean/Cowpea Collaborative

Research Support Program

PN-ABJ-590



10 Years of Collaborative Research

on Beans and Cowpeas

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Bean/Cowpea Collaborative

Research Support Program

PREFACE

The Bean/Cowpea Collaborative Research Support Program (CRSP) is a research and training partnership involving U.S. Land-Grant universities, Host Country agricultural institutions in Africa, Latin America, and the Caribbean, and the United States Agency for International Development (A.I.D.). Host Country and U.S. scientists participating in the CRSP have made long-term investments in the relationships which are the foundation of the program. These investments are both professional and personal as, over the last ten years, these scientists have annually visited one another's laboratories, field sites, and homes. By virtue of this interaction, they have exchanged understandings about their respective cultural and agricultural contexts. Returns generated by these investments have become the foundation for future research and training proposed through 1997.

Various points of view have been shared in thoughtful discussions among these professionals to reinforce research strategies which will contribute to human well-being throughout the world. From the array of diverse national, cultural, ethnic, gender, class, and disciplinary perspectives, their interactions have expanded horizons and opened up exciting new possibilities for the development and application of evolving science and technology.

What is the most significant feature which unites the participants, strengthens the network, and contributes to the successes? There can be no question but that an appreciation of common needs and goals is central. It is apparent that no country can avoid being affected by such problems as worldwide pollution or the social and political effects of severely stressed national economies. Such global issues demonstrate that the U.S. has no immunity from unemployment, poverty, hunger, drought, infestation, and disease suffered by so many other nations. In reality, the U.S. is also a developing country which will benefit from the international sharing of knowledge and resources. In support of such mutually beneficial collaboration between the U.S. and other developing countries, the CRSP has become an effective and impressive model.

The introduction to this document presents basic information about the CRSP and includes a brief history as well as a statement of the current status. The introduction is followed by the updated CRSP Global Plan, on which the program is based, that describes the projects of the CRSP. The third section is a progress report which reviews the projects' achievements

and demonstrates how the accomplishments of the past become the foundation for the future. Growing out of discussions held during the CRSP's International Research Meeting¹ in 1990 and other recent international meetings, critical bean and cowpea research priorities for the next five years have been identified. As the CRSP moves into its next phase, increased communication and continued cooperation in the total global effort can be expected. The result will be a more sustainable and supportive food supply for consumers and farm families in the U.S. and the developing world.

Pat Barnes-McConnell, Ph.D.
Director, Bean/Cowpea CRSP



**All referenced publications available from the Bean/Cowpea CRSP
Management Office (see back cover for complete address)**

*¹Proceedings of the April 1990 Researchers Meeting: 10 Years of
Collaborative Research on Beans and Cowpeas*

TABLE OF CONTENTS

Introduction	1
Brief History	3
Current Status	4
The Global Plan	9
Introduction	9
Articles of the Global Plan	10
Commodity Elements	12
Service Elements	12
Constraint Elements	12
Geographic Elements	13
Project Elements	14
Policy Elements	15
Management Elements	19
Conclusion	20
Progress Report	23
Research Contributions and Next Steps	25
Training Contributions and Gender Response	35
Chart: Degrees Completed	36
Chart: Degrees in Progress	37
Conclusions and Summary of Achievements	41
Contributions to Agriculture in Developing Countries	42
Contributions to Agriculture in the United States	46



INTRODUCTION

In the late 1970s, A.I.D. and what was then the Board for International Food and Agricultural Development (BIFAD), representing the U.S. Land-Grant community, determined that Collaborative Research Support Programs (CRSPs) could provide an exceptional model for U.S. efforts addressing hunger and malnutrition throughout the world. Further, they felt that such a model also could make important contributions to troublesome problems facing U.S. agriculture. Through their commitment to this initiative, eight such programs were organized and funded over the next several years--among them, the Bean/Cowpea CRSP.

From its initiation ten years ago, the Bean/Cowpea CRSP has established an active, interdisciplinary network of U.S. and developing country researchers who are committed to having an impact on world hunger through their work. This partnership, which has attracted additional participation from International Agricultural Research Centers and other national/international research programs, is steadily advancing the science of bean and cowpea production and its application for the small-scale farm families who rely on these commodities for food and income.

CRSP senior scientists from the U.S. bring a unique and important competence to the partnership. Traditionally supported by their commodity industries, they must stay on the cutting edge of technology development. The strong record of publications testifies to the extent of their success.¹ They also must stay in tune with the implications of their work for the farmers of their respective states. Thus, the CRSP community is built on the professional participation of highly respected U.S. scientists who individually have both a basic and an applied orientation. As demonstrated by their many prestigious awards,² they are comfortable and proficient in a context that respects the service as well as the research and teaching dimensions of their disciplines.

SERVICE--For such professionals, it is a relatively small step from a focus on the needs of their states to outreach in service to the hungry around the globe. The service orientation of these scientists is demonstrated by their ready acceptance of the need to focus on technology development useful for the small-scale farmer, especially women--often the major producers of these foods. In the Bean/Cowpea CRSP, the existence of a Women in Development (WID) specialist adds to the resources available to the scientists for carrying out that commitment.³

¹*Bean/Cowpea CRSP Bibliography: Publications, Proceedings, Presentations, and Workshops, 1980-1990*

²*Peer Recognition and Outstanding Achievement Awards*

³*Women in Development*

TEACHING--The significance of the teaching dimension is also apparent.¹ Researchers associated with universities, as befits their traditional professorial roles, encourage the identification of Host Country students and engage their participation in CRSP research.² Following graduation, the return of these students to their home countries contributes significantly to institutional development and, through the maintenance of their relationship with the CRSP, continues to strengthen their national agricultural research programs.

RESEARCH--Careful monitoring of the research has kept the projects on target. The significance of the strong collaboration among U.S. and Host Country scientists cannot be overemphasized as each has brought to the professional relationship important technical, financial, institutional, genetic, and conceptual resources. The interaction of these resources has generated an outcome far greater than the sum of the individual contributions. Indeed, the collaboration, with specific and persistent focus on the long-term objectives, has resulted in substantial scientific and training achievements for the participating nations, the regions, and beyond. Examples are presented in subsequent sections of this document.

The success of the CRSP would not be possible without the competence and dedication of the collaborating Host Country scientists. Equally important is the support of their institutional administrators and the interest on the part of both groups in reaching out to the broad farming community. The senior Host Country professionals have been especially important as they advance the research activities while guiding the re-introduction of the returning graduates into the national legume research programs. Throughout the participating Host Countries, the projects are building in strength and adding important depth and interdisciplinary perspective. In addition, an emphasis on increasing farmer participation is reinforcing the long-term potential for impact.

The 1990 External Evaluation Panel, following its review of field research sites, has given this CRSP its highest rating (Highly Satisfactory). The organization is lean, the management structure efficient, and the research of outstanding quality. Over the past decade, the intensive in-country collaboration, at both the laboratory and farmer level, has generated an increasingly effective understanding of small-scale farm conditions, the demands they place on the family system, and their relationship to poverty and malnutrition. Through shared experience and understanding, Host Country and U.S. counterparts are evolving appropriate responses.

¹*Ten-Year Student Training Report, 1980-1990*

²*Bean/Cowpea CRSP Bibliography: Publications, Proceedings, Presentations, and Workshops, 1980-1990*

BRIEF HISTORY

On September 30, 1980, after two and a half years of planning, the Bean/Cowpea CRSP was initiated. It was charged to engage U.S. universities in partnerships with developing countries to increase the availability of beans and cowpeas, especially for the rural and urban poor who rely on them as important contributions to family diet and income.

The CRSP was based on a Global Plan constructed from input received from U.S. and developing country researchers and administrators (see latest version of the Global Plan in this document). Identified in this Global Plan were the chosen U.S. and Host Country partners and the major constraints to bean and cowpea production and utilization to be addressed through the joint research. The program was to be long term, as required for the difficult problems to be tackled, and was to have a sufficient budget to insure resources necessary to do the job. The original constraints identified were:

1. Limitations due to pests and diseases
2. Plant response limitations
3. Limitations of the physical environment
4. Farming practices limitations
5. Storage limitations
6. Production-consumption economics
7. Nutrition, food preparation, and health
8. Socio-cultural factors
9. Education, training, and research capability

Originally there were eighteen projects, eight in Africa (three bean, five cowpea) and ten in Latin America (nine bean, one cowpea). The relative imbalance of twelve bean to six cowpea projects was considered appropriate as it reflected U.S. research strength.

During the first few years of the CRSP, attention was focused on project establishment, i.e., equipment and vehicles purchased and in place, students identified and enrolled in universities, experiments initiated. By year five, for most of the projects, early results were beginning to emerge. For a few others, serious U.S. or Host Country research or administrative deficiencies had become apparent and were being addressed either through reorganization or termination.

In that year, 1985, the first major budget reduction was levied from Washington. This was handled by issuing the CRSP a seven-month, no-cost extension at the end of that first five-year period, requiring that the CRSP operate on carry-forward funds unspent from the first years of organization. This was the equivalent of a 17 percent reduction in the original commitment.

In May 1986, a new three-year grant was awarded to continue the CRSP work. Less than a year later, there were again significant budget problems in Washington which resulted in a second major budget reduction (20 percent, five months retroactive). This time with significant programmatic impact. All U.S. and Host Country expenditures had to be held to personnel only for nearly three months. In 1989, this grant was extended for another three years, to March 1992, with the initial two years' funding held at the 1987 spending level. However, as of March 1991, owing to the support of Congress and the acknowledgement of CRSP contributions by A.I.D., a major budget increase of 20 percent was awarded which will allow the CRSP to rebuild its weakened structure and respond to new research problems needing to be addressed.

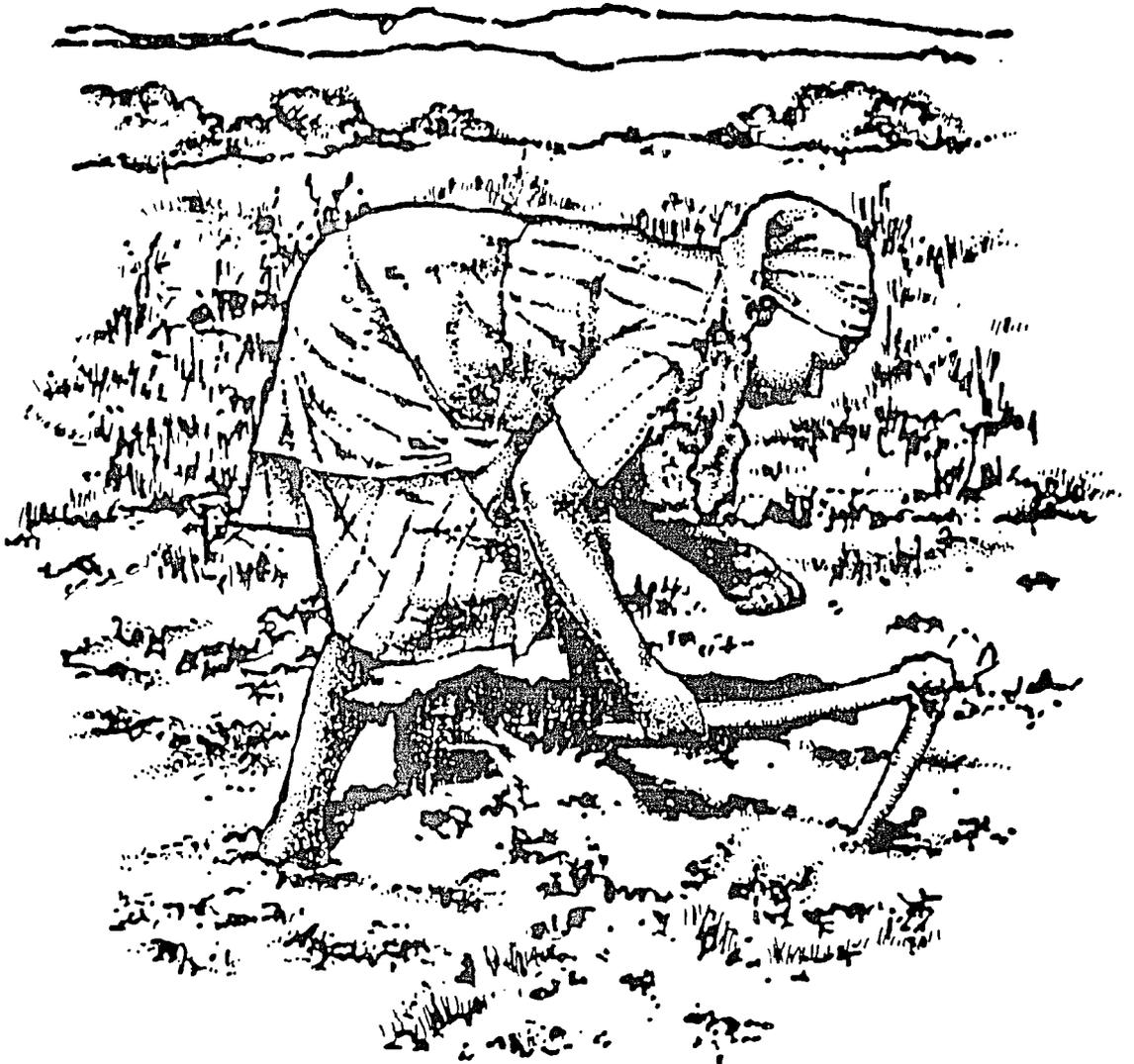
CURRENT STATUS

The commitment to long-term support for the CRSP has allowed most of the projects to fulfill their original, first-phase objectives. Some are now approaching far-reaching achievements unanticipated when the work was begun (the latter heavily influenced by rapidly advancing biotechnologies to which CRSP researchers have contributed). Several times during this ten-year period the Global Plan has been reappraised, particularly in light of the fluctuating financial base. While it was determined that the original constraints were still important, concern for effectiveness required that difficult decisions be made due to the reduced budget.

As of September 30, 1990, there were thirteen projects, five in Africa (two bean, three cowpea) and eight in Latin America (seven bean, one cowpea). The commodity distribution of nine bean projects to four cowpea projects continued to reflect the relative research strength in these commodities in the U.S. Based on new priorities, changes in these projects are being made.

Three major agroecological zones identified in the original Global Plan have been confirmed as appropriate for the continuing CRSP research, although specific sites within these zones have changed as needed. First, communities in tropical areas in East Africa, Latin America, and the Caribbean, where beans are a significant dietary component, have received the most attention. Second, CRSP research has addressed the needs where cowpeas are important in semiarid, rainfed areas of Latin America (i.e., Northeast Brazil) and several countries in West Africa. Finally, there are major issues of concern in the temperate U.S. where farmers traditionally receive significant income from bean or cowpea production and where strong, state-supported research programs on these commodities exist. Between them, these two crops provide a continuum of agroecological possibilities, from semiarid to temperate, for the provision of income, soil fertility, and important protein in human and animal diets.

This document has been prepared in support of an extension of the Bean/Cowpea CRSP through 1997. The progress report presented in section three gives an overview of the many significant achievements for each of the three agroecological regions from the past decade of research. These achievements form the foundation for future work as outlined in the newly modified Global Plan.





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The Global Plan of the Bean Cowpea CRSP

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THE GLOBAL PLAN OF THE BEAN/COWPEA CRSP

INTRODUCTION

The CRSP stimulates and supports commodity-related research collaboration among A.I.D., the U.S. Land-Grant university community (with contributions from the United States Department of Agriculture [USDA]), private institutes, Host Country institutions, and International Agricultural Research Centers. These aggressive collaborative efforts focus on persistent constraints to bean and cowpea production and utilization. This plan presents the organization of the research and management efforts designed to address these constraints in representative agroecological areas of the world where beans and cowpeas are grown.

Program Goal

The Bean/Cowpea CRSP makes available to the international agricultural research and development system a new avenue to the U.S. agricultural research network. In so doing, this CRSP is making important contributions to the resolution of difficult and persistent problems associated with bean and cowpea production and utilization in areas of the world where they are important.

The grant document puts forward the following goal of the Bean/Cowpea CRSP:

The goal of this program is to make a significant contribution to improving the living conditions of small farm producers in LDCs [less developed countries] and increasing availability of low cost nutritious foodstuffs in the marketplace for the rural and urban poor.

Program Purpose

The grant document further identifies the following purpose of the CRSP:

The purpose of this program is to organize and mobilize financial and human resources necessary for mounting a major multi-institutional U.S.-LDC collaborative effort of research and training related to bean and cowpea production and consumption by:

- (1) Linking institutions having common interests in organized programs of research in this CRSP;
- (2) Mobilizing and coordinating the research talent from eligible institutions to ameliorate world food, nutrition, and poverty problems by research in the priority areas of this CRSP; and by
- (3) Achieving optimum collaboration and information exchange by this CRSP with A.I.D. Missions, International Research Centers, and LDC Institutions.

ARTICLES OF THE GLOBAL PLAN

Through collaborative project activity, Host Country as well as U.S. professionals are to be strengthened in their ability to address the constraints by forming productive professional relationships with one another. As first enunciated by the founders of this CRSP, the specific contributions appropriate from these U.S./Host Country partnerships are clear.

1. We must address, collaboratively with LDC scientists, the problems of insect and disease control. We may, in the short term, have to rely upon judicious use of non-persistent pesticides and upon novel means of applying them (for example, pyrethrums and ultra-low-volume spraying); but for the longer term, we must rely on an integrated pest management system which includes breeding pest resistant cultivars, protective farming practices, and biological rather than expensive and toxic chemical control systems.
2. We must support the evolution of sustainable and more productive systems. The evolving systems must maintain biodiversity, and their adaptation to the variety of conditions on small farms, utilizing breeding for higher yields and through improved mixed cropping management.
3. We must address the problem of inefficient nitrogen fixation. In order to escape the tyranny of the spiralling costs of plant nutrients, we can investigate the development of more efficient cultivars as well as nitrogen-fixing bacteria and the evolution of more appropriate farming techniques.
4. We must work to overcome problems of drought through breeding more drought resistant cultivars and the development of farming systems that are efficient and conserving in their use of water.

5. We must work toward better nutritive value and digestibility of the food constituents of beans and cowpeas through breeding and use of Food Science research to identify and study traits, important to improve acceptability and nutrient quality.
6. We must work to overcome or minimize the problem of hard seeds and long cooking time in beans and cowpeas through both breeding and the use of simple storage or processing tactics in order to reduce cooking time and fuel requirements.
7. We must promote the creation or operation of seed multiplication programs in order to reach the small farmers with seeds of improved cultivars that are not only genetically superior but that are of sound physical quality and free of seed-borne diseases. The issues of seed availability and credit to women for seed purchases must also be addressed.
8. We must help evolve methods of storage and of food preparation that conserve the full value of the dry grains without insect depredation, or fungal infestation and that permit retention of full nutritive capability of these grains (or other plant parts, as applicable) when made ready for consumption. There must be no marked alteration in the grains that detracts from their acceptance and safety as food.
9. We must be cognizant of the interacting and sometimes contradictory results of various technological interventions. We must, therefore, carry out production/consumption-oriented research with socioeconomic analysis to assess the acceptability and agroeconomic feasibility of proposed interventions. Marketing studies should determine whether improvements, in terms of greater real gain to the farmer, can be made in the system.
10. We must give substantive consideration to major components of the farming system and especially the human components. We must become sensitive to and knowledgeable about the unique and multiple roles played by women, men, and children in developing countries as they affect production and utilization of beans and/or cowpeas.
11. We must attempt to maintain an acceptable ecology by encouraging all collaborators to look specifically at the relationship of their research to the agronomic, social and cultural context of the small farm family. Researchers will have to assess the potential of their research for increasing or lessening the frequently overwhelming burden of daily living for such families, an assessment which will suggest the level of acceptance that can be anticipated.

12. We must address a serious problem of research personnel availability by supporting the training of indigenous professional and technical personnel. Trainees at all levels, including post-graduate students, will need to be supported in order to help build a supply of skilled individuals, both men and women, who can conduct useful and needed research and demonstration work with beans and cowpeas.
13. We must facilitate the institution building and development of collaborative relationships, not only between U.S. and Host Country scientists, but cross-nationally among LDC scientists themselves, and among U.S. scientists as well. The resulting networks will address the major constraints in cowpea and bean production and utilization.
14. We must facilitate the introduction of biotechnology where appropriate to the relief of constraints of beans and cowpeas.

COMMODITY ELEMENTS

It was determined that *Phaseolus vulgaris* and *Vigna unguiculata* would be the focus of this program. Although there are other legumes to which research could make an important contribution, these two were considered the most critical ones worldwide and the ones for which research expertise was most available in the U.S.

SERVICE ELEMENTS

A major goal of the program is to improve the well being of small-scale farmers in developing countries through increasing their capacity to produce, utilize, and market beans and cowpeas. In many contexts, meeting this goal requires that special attention be paid to women's roles in agriculture. In Africa especially, women often bear the primary responsibility for the production of legumes and other food crops consumed by their families.

Directing research to meet the needs of small-scale farm families requires a multi-disciplinary approach involving social and biological scientists, nutritionists, food technologists, and others. This multidisciplinary research process yields results which not only benefit developing countries but also find application in U.S. agriculture.

CONSTRAINT ELEMENTS

The major constraints to bean and cowpea availability were identified through communications with Host Country scientists, visits to the farming communities, and extensive documentation searches. This information was

set forth in the resulting state-of-the-art publication (Adams, M. W. 1984. *Beans-Cowpeas: Production Constraints and National Programs*. East Lansing, Michigan: Michigan State University, Bean/Cowpea CRSP Management Office). Its early draft became the basis for the development of projects in representative regions.

The researchable constraints are reviewed regularly and modified as necessary. Currently the constraints are as follows:

1. Limitations due to insects
2. Limitations due to diseases
3. Plant response limitations
4. Limitations of the physical environment
5. Production-consumption economics, farming systems, socio-cultural factors
6. Storage, food preparation, nutrition, and health
7. Education, training, and research capability

GEOGRAPHIC ELEMENTS

Because sensitivity to daylength, temperature, and rainfall patterns are important in the adaptation of beans and cowpeas, countries providing a range of agroecological conditions were chosen for the research. In addition to the U.S., the Host Countries participating in this CRSP as of the date of this publication are:

<u>AFRICA</u>		<u>LATIN AMERICA/CARIBBEAN</u>	
Cameroon	Senegal	Brazil	Guatemala
Malawi	Tanzania	Dominican Republic	Honduras
Nigeria		Ecuador	Mexico

Collaborating with the programs in these African and Latin American nations are the following U.S. institutions:

Boyce Thompson Institute
 Cornell University
 Michigan State University
 Purdue University
 University of California-Davis
 University of California-Riverside
 University of Georgia
 University of Minnesota
 University of Nebraska
 University of Puerto Rico
 University of Wisconsin
 Washington State University

PROJECT ELEMENTS

The CRSP is divided into individual, but coordinated, projects organized to carry out research on constraints in countries representative of where these constraints are important and where the expertise to collaborate exists. Each project is organized under the management of a U.S. lead institution with a U.S. Principal Investigator (PI) to lead the conduct of the joint research in the constraint area. In the Host Country, a counterpart PI is named to be responsible for project collaboration and Host Country activities. CRSP projects as of this date are listed below.

<u>Title of Project</u>	<u>Host Country/U.S. Institution</u>
Insect Pathogens in Cowpea Pest Management Systems for Developing Nations	Brazil/Boyce Thompson Institute ¹
Preservation of Post Harvest Cowpeas by Subsistence Farmers in Cameroon	Cameroon/Purdue University
Biology, Epidemiology, Genetics, and Breeding for Resistance to Pathogens of Beans with Emphasis on Those Causing Bacterial and Rust Diseases	Dominican Republic/University of Nebraska-Lincoln
Molecular Approaches for the Control of Bean Golden Mosaic Virus	Dominican Republic/University of Wisconsin-Madison
Improving the Productivity of <i>Phaseolus</i> Beans Under Conditions of Low-Input Agriculture Through Genetic Selection of Host Cultivars and Rhizobium Strains for Enhanced Symbiotic Efficiency	Ecuador/University of Minnesota
Agronomic, Sociological, and Genetic Aspects of Bean Yield and Adaptation	Guatemala/Cornell University ²
Improvement of Bean Production in Honduras Through Breeding for Multiple Disease Resistance	Honduras/University of Puerto Rico
Improving of Dry Bean Nutritional Quality and Acceptability	INCAP/Washington State University ¹
Improvement and Host Pathogen Co-Adaptation in Malawi, a Secondary Center of Diversity	Malawi/University of California-Davis
Improving Resistance of Environmental Stress in Beans Through Genetic Selection for Carbohydrate Partitioning	Mexico/Michigan State University
Appropriate Technology for Cowpea Preservation and Processing and a Study of Its Socioeconomic Impact on Rural Populations	Nigeria ³ /University of Georgia
A Program to Develop Improved Cowpea Cultivars, Management Methods, and Storage Practices for Semiarid Zones	Senegal/University of California-Riverside
Breeding Beans (<i>Phaseolus vulgaris</i> L.) for Disease, Insect, and Stress Resistance and Determination of Socioeconomic Impact on Smallholder Farm Families	Tanzania/Washington State University

¹Project being reorganized and relocated in FY 92

²Project completed in FY 92

³Project completed in Nigeria, FY 91 and relocated to Ghana

POLICY ELEMENTS

The following policies, developed by the CRSP Board of Directors, undergird the program and facilitate its functioning in line with program objectives.

1. Bean/Cowpea CRSP Policy on Collaboration

Bean/Cowpea CRSP projects should be collaborative with U.S. and Host Country partners rather than free standing in any one country. The cross-national teams are to collaborate in the planning and implementation of the research and in budget decision-making.

2. Bean/Cowpea CRSP Multidisciplinary Policy

Because of the complex nature of the food and agriculture issues addressed, the CRSP is encouraged to continue a multidisciplinary orientation in its projects and program-wide activities. Broadly, within the CRSP an integration of the production sciences (e.g., pathology, physiology, breeding) and the non-production sciences (e.g., food science, social science including economics) should be maintained through research and program management.

3. Bean/Cowpea CRSP Women-in-Development Policy

In many parts of the world, the primary responsibility for bean and cowpea production rests with women. A major commitment is made by the Bean/Cowpea CRSP to the participation of women in its research projects and training opportunities. Attention to the effects of the Program on family life is a major concern. A Women in Development Specialist is essential in the implementation of this policy.

4. 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 Bean/Cowpea CRSP Board of Directors 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.

5. Bean/Cowpea CRSP Policy on Institutional Involvement

The 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 each lead institution is aware of the progress. Every institution is strongly encouraged to take significant steps 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 evaluations.

6. Bean/Cowpea CRSP Policy on U.S./Host Country Distribution of Funds

- a. Based on each grant period, not less than 50 percent of USAID funds for support of projects is to be spent in or directly on behalf of Host Countries in order:
 - (1) To insure CRSP focus on the solution of Host Country problems rather than on the maintenance of existing research programs of U.S. institutions; and
 - (2) To nourish a climate of collaboration and partnership between the U.S. and Host Country PIs.
- b. However, experience has demonstrated that the U.S. PI is uniquely restricted when institutional indirect costs for project support are taken solely from the U.S. portion of the funds. Therefore, the 50/50 split policy is to be applied to the total project budget exclusive of all indirect costs.
- c. Some projects have not settled into a spending pattern in the Host Country comparable to that in the U.S. Thus, in order to maintain a 50/50 split, more of each year's funds must be allotted to the half of the team spending less. Assuming that authorized project spending suggests the progress of approved research activity, it is appropriate to encourage Host Country utilization of project funds.

Therefore, where Host Country spending patterns are seriously below the expected level, the Host Country and U.S. PIs will be requested to submit to the MO for TC discussion the reasons for

the unbalanced spending patterns. They should present their suggestions for addressing the issue, including possible recognition that the Host Country budget level is unrealistic.

7. Bean/Cowpea CRSP Project Allocations Policy

If there is an effective and consistent quarterly spending pattern of 80 percent (actual costs reimbursement not including encumbrances), subject to the availability of funds, projects may be considered for allocations up to 100 percent of project need as requested and demonstrated by the PI. Maintenance of spending patterns less than 80 percent receive allocations commensurate with the prior spending pattern at a level which will discourage the accumulation of excess carry-forward funds.

8. Bean/Cowpea CRSP Policy on Contribution of Host Country Institutions

While not specifically mandated as in the case of U.S. institutions, contributions from participating Host Country institutions are encouraged and are seen as strengthening the collaborative nature of the CRSP. In-kind contributions and indirect costs or overhead are among the contributions considered appropriate.

9. Bean/Cowpea CRSP Training Policy

The Bean/Cowpea CRSP has as a major goal the strengthening of Host Country institutions through the training of Host Country 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 U.S. persons. This policy adopts a Host Country priority rather than U.S. exclusion and refers to both short-term training and graduate education.

10. Bean/Cowpea CRSP Policy on Location of Sponsored Graduate Training

It is in the best long-term interest of each Host Country institution that its personnel achieve training from a diversity of institutions in an effort to avoid institutional "in-breeding." CRSP lead institutions and their Host Country collaborators are encouraged to consider using an assortment of different CRSP training sites for nationals from the same Host Country.

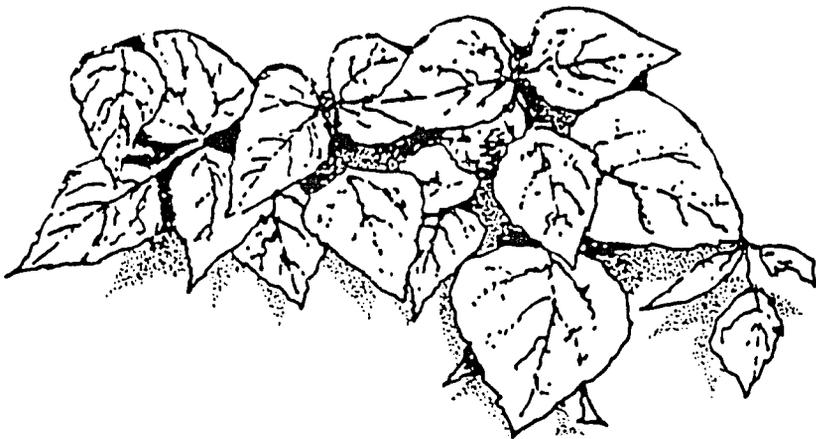
11. Bean/Cowpea CRSP Policy on Student Support

The Bean/Cowpea CRSP BOD endorses the honoring of training commitments made to Host Country students associated with projects which are terminated prior to the completion of the students' programs. This policy is in effect only for the academic degree for which the students are studying at the time of their projects' termination. A total maximum commitment is not to exceed five years for the Ph.D., three years for the Masters, and five years for the Baccalaureate degree. This policy is contingent upon the continuation of the CRSP, the availability of funds, and satisfactory academic progress by the trainee.

12. Bean/Cowpea CRSP Policy on Institutions Formerly Associated with the CRSP

Institution building, through (1) professional training and (2) financial investment in research infrastructure, is an important objective of the CRSP. As such, when a CRSP project comes to an end, a CRSP-generated institutional capacity, beyond that originally in place when the project began, should be evident.

To reinforce this increased capacity and its potential for ongoing contributions to CRSP goals, the CRSP network is expanded to include former CRSP institutions as CRSP Alumni. The designation of institutions as CRSP Alumni shall be at the invitation of the BOD and effective only upon the formal acceptance by the designated institution. Subject to the availability of funds, each year limited financial support for Host Country alumni institutions will be made available for specific, approved uses in order to reinforce the CRSP Alumni role.



MANAGEMENT ELEMENTS

The grant for the Bean/Cowpea CRSP was awarded to Michigan State University (MSU), thereafter known as the Management Entity (ME), the entity legally responsible for the CRSP. The unit receiving the grant was the College of Agriculture and Natural Resources which subsequently established an office and staff, thereafter known as the Management Office (MO), which is operationally responsible for the conduct of the CRSP.

The MO, on behalf of the ME, is the link between A.I.D. and the projects of the CRSP. The staff is comprised of a Program Director, a Deputy Director, an Administrative Officer, and secretarial staff. A separate Research Support Unit includes a Women in Development (WID) Specialist and an Agricultural Economist (added in 1991).

The projects of the CRSP are funded and organized through subcontracts to U.S. lead institutions. These lead institutions, in turn, subcontract further with other approved U.S. institutions participating in their projects and the obligatory Host Country partner institutions in Africa, Latin America, or the Caribbean.

The CRSP management is reinforced by three advisory groups, all of which are supported by the MO. These groups are the Board of Directors (BOD), the Technical Committee (TC), and the External Evaluation Panel (EEP).

BOD - The membership is five administrators, four of whom serve rotating terms. They are the designated Institutional Representatives from the lead institutions. The remaining one is a standing member--the Institutional Representative, or designee, from the ME. The BOD is the policymaking body of the CRSP.

TC - Elected by their peers and approved by the BOD, the TC guides the technical aspects of the CRSP and monitors the conduct of research. Five of the seven members are scientists from the diverse disciplines participating in the projects (one of whom is from a Host Country). The remaining two are representatives from each of the two relevant International Agricultural Research Centers (IARCs): the Center for Beans in Colombia (CIAT) and the Center for Cowpeas in Nigeria (IITA).

EEP - Five senior development specialists, charged by A.I.D. to conduct routine evaluations, make up the group which annually assesses the research and training progress of the CRSP. They review the projects at both U.S. and Host Country sites and assess the effectiveness of CRSP management.



CONCLUSION

The Global Plan is the foundation of the Bean/Cowpea CRSP. The policies and the broad management structure reinforce its organization and operations. While the constraints identified are important country-specific issues, they exist throughout the world wherever beans and cowpeas are grown. By distributing research attention to these constraints across the agroecological zones represented by the CRSP countries, principles are elucidated which have application throughout the legume-producing world. Research collaboration, therefore, can be of great benefit to many countries. In particular, CRSP collaboration has demonstrated that there is as much specifically for the U.S. to learn and gain from traditional settings and Host Country scientific expertise, as there is for U.S. research to contribute. Thus, through its partnerships, the CRSP supports an expanded international agricultural research community that is likely to continue generating benefits well beyond the life of the CRSP itself.

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Progress Report

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PROGRESS REPORT

The latest Annual Report of the Bean/Cowpea CRSP¹ presents the array of CRSP achievements and their implications which form the foundation for the next extension period. Examples of these achievements are listed at the end of this document and demonstrate the value of the sharp research focus that has been maintained. However, staying totally isolated within a narrow, disciplinary niche would have diluted both the effectiveness of the research and its usefulness. The CRSP, therefore, has not only built an interdisciplinary organization, it has also concentrated on building linkages with other entities that can broaden its impact, e.g., IARCs, private organizations. These linkages have been extremely productive for all parties. Further, through a newly formed CRSP Council, the Bean/Cowpea CRSP is cooperating with the other Collaborative Research Support Programs to build integrated research initiatives.

All the projects of the Bean/Cowpea CRSP maintain three important characteristics. First, they are highly interactive with one another, e.g., exchanging students, germplasm, methodologies, and analytical services. Second, they share financial resources between the U.S. and Host Country institutions, allowing both partners to operate effectively. Finally, they integrate research and degree training so that project and student research are mutually supportive and returning graduates are prepared to continue contributing to CRSP research objectives at the home site. This orientation will continue.

Maintaining a basic level of support for the most productive projects has been of highest priority. This was true even when it was done necessarily, at the expense of others that also may have had great potential. Because stubborn problems require long-term research, steady support for older, but still important, priorities which are approaching pay-off was considered crucial. Thus, the level of accomplishments continued.

Concurrently, however, a watchful eye was kept on the ever-changing global context and the need for new priorities important for achieving stated objectives. Thus, a program for the nineties has emerged which builds on the past CRSP accomplishments and orientation, acknowledges achievements from the broader international research complex, and considers all of these in light of the evolving vision within A.I.D., the Board for International Food and Agricultural Development and Economic Cooperation (BIFADEC), and the international development community.

¹*FY 90 Annual Report: 10 Years of Collaborative Research on Beans and Cowpeas*

Now increasingly, assessments of traditional western agriculture have noted that, while able to feed masses of people, such agriculture is not without its costs. Some of those costs have been found to degrade unacceptably the natural resources on which agriculture itself depends and, thus, have generated calls for greater sustainability, i.e., an agriculture that provides for the world's need for food and related products in a way that maintains, if not enhances, the natural resource base.

This new vision for agriculture, although much broader in scope than the Bean/Cowpea CRSP, is nonetheless highly compatible with the original CRSP philosophy as enunciated in the "Articles of the Global Plan." These Articles were the original basis of CRSP project development and directed attention to the development of sustainable technologies, e.g., new cultivars with resistance to pests and diseases, protective farming practices, and biological pest control systems.



RESEARCH CONTRIBUTIONS AND NEXT STEPS

Researchers throughout the U.S. have attested to the positive impact that the CRSP has had on virtually every public and private bean and cowpea program in the country. Benefits are both basic and applied and help buffer past genetic erosion in the U.S. Likewise, contributions to participating developing countries and other developing countries in their regions have been substantial.

It is not surprising, therefore, that increasing interest has been shown by non-participating countries and USAID Missions in "buying-in" to the CRSP. These groups have felt that the potential for CRSP research and training to contribute to their own needs is sufficiently great to justify the commitment of their own funds to the CRSP. Recently, there have been several such buy-ins with several more currently under negotiation. Integration of such external but related research interests will be increased.

The specific constraints which are the focus of CRSP research fall into five categories which are important if more sustainable systems are to be achieved. While most of the CRSP projects address more than one of these constraints to some degree, the projects are shown below only under their principal constraint areas. It is worth noting that constraints listed under Resource Conservation and Management have moved up to first place from their previous position ten years ago, reflecting the new priorities discussed above.

Resource Conservation and Management

*Constraints: Limitations of the Physical Environment
 Plant Response Limitations*

*Projects (5): ECUADOR, GUATEMALA, MALAWI, MEXICO
 and SENEGAL*

As a major center of bean diversity, MALAWI has provided a context for the biological and socio-cultural study of (a) genetic diversity and (b) factors that account for, and support, that diversity. CRSP biotechnology demonstrated that the two major gene pools of *Phaseolus vulgaris* are distinct. Studies of co-adaptation of host bean varieties and their disease pathogens are underway. Similarly, studies of farmers' perceptions and management of those bean diseases is contributing to the design of cultural and low-input control measures. The role of beans in small-scale farm families has been documented and the attention of breeders has been directed to the characteristics of importance. Screening for yield, disease and pest resistance, nodulation ability, drought, and hard seed coat is included in the germplasm research which is as important for MICHIGAN and other bean-producing states in the U.S. as it is for MALAWI and other

developing countries. A recent CIAT paper reports **MALAWI** has been increasing per/hectare bean production over the last decade. CRSP Host Country and U.S. researchers have contributed to this growth. The project's U.S. leadership (originally directed by a CRSP co-founder from Michigan State University, now retired) recently was awarded to a strong bean genetics team at the University of California-Davis. This change followed an open competition in which the Host Country PI participated in the selection. Integrated genetic and socio-cultural research will continue as the basis for the subsequent work of this project.

Research on the physiology of bean yield has improved the ability of breeders to exploit genetic potential for different ecological environments. A new methodology, "Yield System Analysis" (YSA), has been used to develop new high-yielding varieties for the moist, hot environment near sea level as well as for highland farmers at cooler temperatures where early maturity is important. In the latter case, the coalition of high yield and early maturity in CRSP-developed varieties is making it possible for farmers in **GUATEMALA** to begin growing two plantings of beans a year rather than one. The research has resulted in at least one variety in **NEW YORK** with a 30-40 percent yield advantage over previous lines grown commercially there and which also gives promise of being a superior canning product. With original theoretical and basic objectives being achieved, this project is being phased out. New studies on the yield potential in beans are not being proposed at this time.

Collections of wild beans for future crossing to increase genetic variability are of concern to the **MEXICO** research team as are the international bean genotype collections from Central and South America and CIAT. Progress has been made in the release of bean varieties for rainfed conditions in the Mexican highlands where insufficient or unpredictable rainfall is common. The research challenge is demonstrated by the existence of many mechanisms that support drought resistance and drought avoidance. One such mechanism studied by the CRSP, deep rooting, is important in both **MEXICO** and the U.S., and is assisted by germplasm with root systems resistant or tolerant to root-rotting pathogens. Three cultivars released in **MEXICO**, from germplasm which also appears to be useful for **MICHIGAN**, have been successful as demonstrated by the increased demand for seed by private sector seed producers and the public. In the extension period, the breeding program will continue to emphasize drought avoidance and the physiological and morphological components of adaptation, water-use efficiency, nitrogen fixation, grain yield, and total biomass production. Studies of nitrogen and carbon remobilization in water-stressed genotypes also will be continued as an important part of this work.

In response to even more severe environmental stress in semiarid areas, cowpeas too are being bred for adaptation to drought as well as for improved heat tolerance. This work has benefitted both **SENEGAL** and

the **CALIFORNIA** cowpea industry. Management methods have been recommended and are part of CRSP "mini-kit" technology being evaluated by Senegalese social scientists. During the severe drought of the mid-1980s, USAID and the European Economic Community (EEC) purchased from **CALIFORNIA** farmers, 700 tons of California Blackeye #5 cowpea seed which CRSP researchers had determined to be adapted to **SENEGAL**. This variety, distributed to Senegalese farmers, yielded well and was reported to have saved over a million Senegalese from starvation and to have brought a 63 percent return on the dollar investment. Extensive germplasm collections now have been made. An advanced cowpea line with resistance to cowpea weevil, bacterial blight, and certain mosaic viruses has completed two years of multi-location on-farm testing and is ready for official release. That variety, No. 275, also gives greater yield stability than older varieties and evidence of strong resistance to the parasitic weed, *Striga*. Statistics from **SENEGAL** indicate production of cowpeas during the next three years was 30 percent greater than production during the prior ten years. During the extension period, the breeding program will incorporate more basic physiological and genetic research to hasten the development of improved lines. Additional efforts are underway to reach the farmers and strengthen agronomic and socioeconomic studies in support of the breeding program.

A CRSP project on biological nitrogen fixation achieved all of its objectives in the first decade, generating an especially high nitrogen-fixing, small-seeded black bean for Latin America and, equally important, improved germplasm taken over by the bean seed industry in **WISCONSIN**. The project also identified a new protein, arcelin, which may prove important in developing cultivars resistant to storage weevils. In recognition of his outstanding work, the U.S. PI was offered, and accepted, an endowed chair at another institution, which required a career change de-emphasizing



bean research. Previously working in **BRAZIL**, the project now is reorganized under the leadership of scientists from the University of **MINNESOTA** and **ECUADOR**. It now is emphasizing nitrogen fixation in large-seeded bean types and has begun by carrying out baseline soil studies in several regions in **ECUADOR**. Over the next five years, studies will include molecular techniques to explore and explain the basis of cultivar differences in nitrogen fixation, host/strain interaction in acid pH soils, and cultivar response to low P levels. Attention is also being given to biodiversity among Ecuadorian bean rhizobia, competition between *Rhizobium* inoculant strains and the native strains already in the soil, and the extent to which root disease is a limiting factor in nitrogen fixation. Breeding for high nitrogen-fixing lines, utilizing disease resistant material, will continue during the extension period.

Crop Production

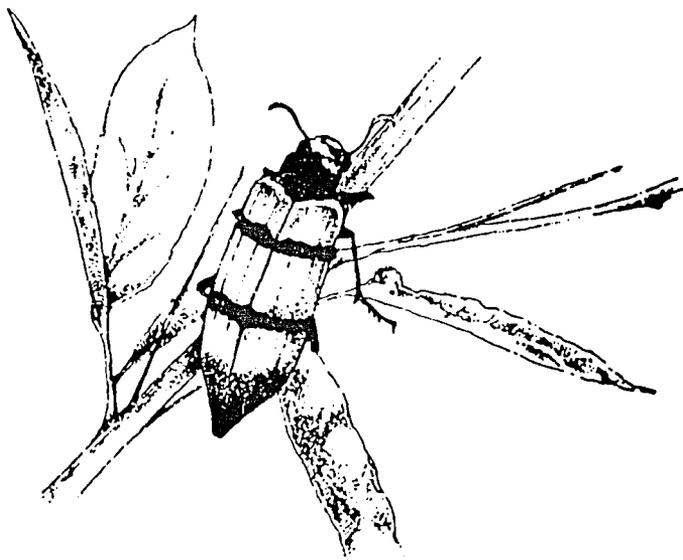
*Constraints: Limitations Due to Insects
 Limitations Due to Diseases
 Crop Management and Production Economics
 Limitations*

*Projects (5): BRAZIL, DOMINICAN REPUBLIC (2),
 HONDURAS, and TANZANIA*

Integrated Pest Management - Previous CRSP efforts in **BRAZIL** in biological insect control have concentrated on fungal pathogens of cowpea insects. Nearly 300 isolates have been collected, some of which, in addition to infecting cowpea insects, are very effective on bean insects in more humid areas. Others of these isolates, according to USDA, show promise for other crops in the temperate U.S. Their effectiveness as part of an integrated pest management (IPM) scheme in **NEW YORK** and **ILLINOIS** was demonstrated. However, the pathogens have not proven effective in the drier areas where cowpeas are grown. Thus, other biological control methods will be sought. With significant objectives for fungal control achieved and with the remaining ones determined to be more of a "long-shot" for the current location, the management advisory groups recommended this research be redirected. Therefore, the project is phasing out and will be replaced with a reorganized cowpea IPM project for the extension period which incorporates other methodologies that could be more appropriate for areas where cowpeas are grown.

Disease Control - Several years ago a new, CRSP-developed cultivar, PC-50, was released in the **DOMINICAN REPUBLIC** and distributed to farmers by the Ministry of Agriculture. Last year 60 percent of the dry bean crop was planted to this cultivar. Of 52 growers surveyed, 92 percent liked PC-50 because of high yield, seed purity, large seed size, and attractive color, wide adaptation and type of plant architecture which discourages the growth of

white mold. The mean yield among the randomly chosen, surveyed growers was 987 kg/ha last year compared to 505 kg/ha mean country yield for the period 1978-1988. Major progress has been made by the research team in studies of rust and other diseases of beans, particularly bacterial diseases. Leaf pubescence (hairiness) was found to render rust resistance to beans. The genetics of this durable trait for resistance was determined. The team has released a new Great Northern dry bean cultivar, "Starlight," in **NEBRASKA**, which has had favorable grower response. This seed, larger and a brighter white than any currently grown cultivars, is expected to give **NEBRASKA** a competitive edge in foreign markets where this quality is of primary importance. Improved germplasm with multiple disease resistance has been shared with the rest of the CRSP bean projects, other U.S. and national programs, and international research centers. Work will continue into the extension period with additional lines soon ready for release. Basic research on disease mechanisms will continue as will studies of improved management practices for disease control.



In **TANZANIA** where extensive genetic bean diversity exists, field trials continue to provide data for validation of the YSA methodology developed by the CRSP **GUATEMALA** project. Researchers have over 40 high performance, multiple-disease-resistant lines in advanced yield trials, ten being evaluated for acceptance and three slated for release. One of these cultivars currently being increased for release has yielded more and withstood drought better than farmers' local varieties and, in addition, cooks faster, and is judged to have comparable taste. Unusually variable weather with floods and drought in the same season is putting a great deal of stress on the crops. The need to work closely with farmers in making research decisions is clear and, therefore, a farmer-participatory model is an integral part of the project. Trials with rhizobia inoculant **NITROSUA**

developed by the CRSP Sokoine team continue to show great promise in different parts of the country. The inoculum is being produced in a pilot plant at Sokoine University of Agriculture and is being distributed to growers throughout the country at minimal cost. In the U.S., using technology developed under partial CRSP support, virus diagnosis and serotype identification of suspicious vegetative tissues and seed lots has become routine in the **WASHINGTON** State Crop Improvement Association and **WASHINGTON** State Department of Agriculture Phytosanitary Certification Programs. They are being used by other states' regulatory agencies as well.

Molecular characterization of specific viruses, a major problem throughout bean growing areas in Latin America, is progressing rapidly. Molecular probes to detect and identify viruses have been developed. The probes now are being used to assist viral research in programs all over the developing and industrialized world. The improved pathogen detection methods developed apply to other crops as well as beans and allow better disease control strategies. A private firm, Agracetus, Inc., has been collaborating with researchers at the University of **WISCONSIN** in developing new particle-gun technology for the much more rapid development of virus-resistant cultivars than has been possible in the past. This work will continue in the extension. The major focus will be directed toward using recombinant DNA technology to develop virus-resistant beans. This project is developing a formal network of scientists (**DOMINICAN REPUBLIC, JAMAICA, GUATEMALA, COSTA RICA, HONDURAS, NICARAGUA, BRAZIL**) studying bean-infecting geminiviruses and strengthening the biotechnology capabilities of scientists in Central America and the Caribbean to address this very serious rapidly spreading disease.

Research at the University of **PUERTO RICO** is concentrating on small red beans popular in Central America. It is generating varieties with greater yield potential and enhanced levels of resistance to multiple diseases important in that region including a wide range of bean common mosaic virus (BCMV) strains. Initial efforts focused on identifying germplasm which had resistance to indigenous strains and races of disease pathogens. Subsequently, research has been able to emphasize breeding this resistance into improved lines. For example, bean rust races in **HONDURAS** are among the most virulent in the world. All major sources of specific rust resistance are susceptible there. In the extension period, crosses between these lines and lines with dense pubescence (hairiness--see Dominican Republic information above) are planned to combine BCMV resistance with non-specific resistance to rust. In the U.S. many of the diseases are the same as in the tropics but screening in the tropics is more efficient because of greater severity and predictability of infection there. Scientists collaborating with the CRSP **DOMINICAN REPUBLIC** project are evolving methodologies useful for the development of small red lines, some of which are being grown in the U.S. In **HONDURAS** where small reds are generally

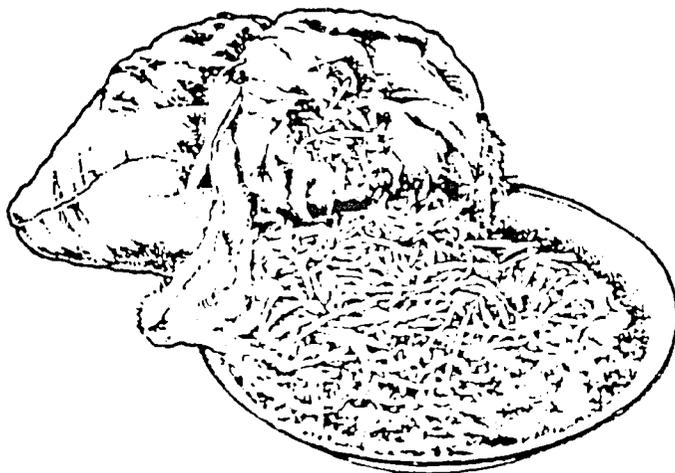
grown by small-scale farmers, the breeding lines developed are being tested on small farms through cooperation with the Ministry of Natural Resources. Following their release, this research will continue combining resistances, especially to environmental stress and seed-borne diseases, since most farmers grow their own seed. Farm-level socio-agronomic studies are being integrated with this work.

Post-Harvest Protection, Processing, and Nutrition

Constraints: Storage, Food Preparation, and Health Limitations

Projects (3): CAMEROON, INCAP, NIGERIA

In **INDIANA**, Purdue University is conducting research for the development of effective storage technology for **CAMEROON** and other cowpea-growing regions. Clarification of (1) the storage practices used in the northern region, (2) the persons in the household responsible for production and storage, and (3) the methods currently used to mitigate losses is assisting this work. Because of the complexity of the small-scale farming context, attention is being paid to multiple responses to storage technology needs. These include the development of a breeding program for seed and pod resistance to cowpea weevil, delineation of the conditions under which ash (traditional technology) as a storage medium is the most effective, and the development of solar disinfestation technology which, through fabrication of a solar heater, uses simple, easily available, and inexpensive materials. The solar heater which the team developed is likely to be useful for other stored crops as well as cowpeas. This emphasis on storage pests grew out of a CRSP project on field insects, previously under the leadership of another U.S. institution, which was reorganized in 1987. This research is strengthening the ability of farmers to store cowpeas longer, with less loss of quality and less need to sell at harvest when prices are lowest, or buy poor



quality seed late when prices are highest. It will include continued screening of exotic and local germplasm, breeding for seed and pod resistance, farmer participation in research design and evaluation, and the search for genes which through genetic engineering can bring new sources of bruchid resistance into cowpeas (and beans). Large numbers of farmers are showing significant interest in the evolving technologies.

Objectives related to the development of appropriate technology for cowpea processing have been accomplished in one location. Interested new locations are being evaluated for additional work. Four village mills for processing cowpeas into a flour with the proper consistency for producing traditional foods acceptable to consumers were developed and installed (two with the help of AFRICARE) in two states in **NIGERIA**. The product had 100 percent acceptability in consumer tests, reduced preparation and cooking time, and reduced flatulence. Acceptance among children studied was enthusiastic. Project products (particularly improved cowpea flour and splits, infant weaning foods, and supplements formulated and tested by the Host Country team) are increasingly being used by roadside vendors of popular cowpea foods and in maternity and child rehabilitation clinics in the two states. Small-scale production is expected to be stimulated by the presence of the mills in the rural areas which demand cowpeas and cereals as raw materials and provide a dependable market outlet for small growers. Representatives from the U.S. food industry found the Nigerian food product made from the flour a good candidate for the U.S. fast food market. With the technology for enhanced cowpea processing in place, it was determined that further dissemination must be left to others, e.g., the private sector. The **GEORGIA** research team is turning to a new site needing value-added technology to support small-scale producers.

Research collaboration among several U.S. institutions in **WASHINGTON**, **KANSAS**, and **MICHIGAN** working on bean quality have (1) helped define food quality standards for dry beans, (2) advanced methodologies for assessing dry bean quality, and (3) established standard experimental protocols for use by bean breeders. **INCAP** in **GUATEMALA** has made important contributions to the work and closer cooperation between plant breeders/geneticists and biochemists/nutritionists has been established through these efforts. In addition, assessments of evolving new genotypes for other CRSP projects and for national/international research centers breeding improved varieties have been provided. The contributions of these different programs have been varied and useful. However, greater focus and concentration of effort are needed. Thus, this project is being phased out and a more limited project that builds on the previous project's research results is being developed.

Socio-Cultural Influences and Indigenous Knowledge Systems

Constraints: *Socio-Cultural Issues, WID, Farmer Participation*

Projects (2): **MALAWI, TANZANIA**
 (joint focus under two constraints)

Research activity in MALAWI and TANZANIA has generated considerable information on indigenous knowledge, the roles and needs of women producers, and other socio-cultural aspects of the farming system that impact the availability of beans. This information is being incorporated into the bean improvement program. Many of the other projects of this CRSP, now reasonably far along in their biological program, also have begun to include this perspective in their research design in a functional way (e.g., CAMEROON, SENEGAL, ECUADOR). A farmer-participation model is evolving which integrates farmer criteria in evaluation of breeding lines in TANZANIA.

The CRSP WID program, a cross-project effort within the CRSP, provides information on gender and social science issues and assists PIs in identifying Host Country researchers to help meet their needs in these areas. Technical support from this component is provided to the overall program through the Technical Committee where the WID specialist is a standing member, through interaction with the Management Office, and through participation in workshops and conferences. The primary research carried out by the WID specialist provides not only information important to the biological research in that location, but also provides a demonstration of how that contribution can be effective. WID scholarship is making additional contributions to the integration of the biological and social sciences.

Institution Building and Human Resource Development

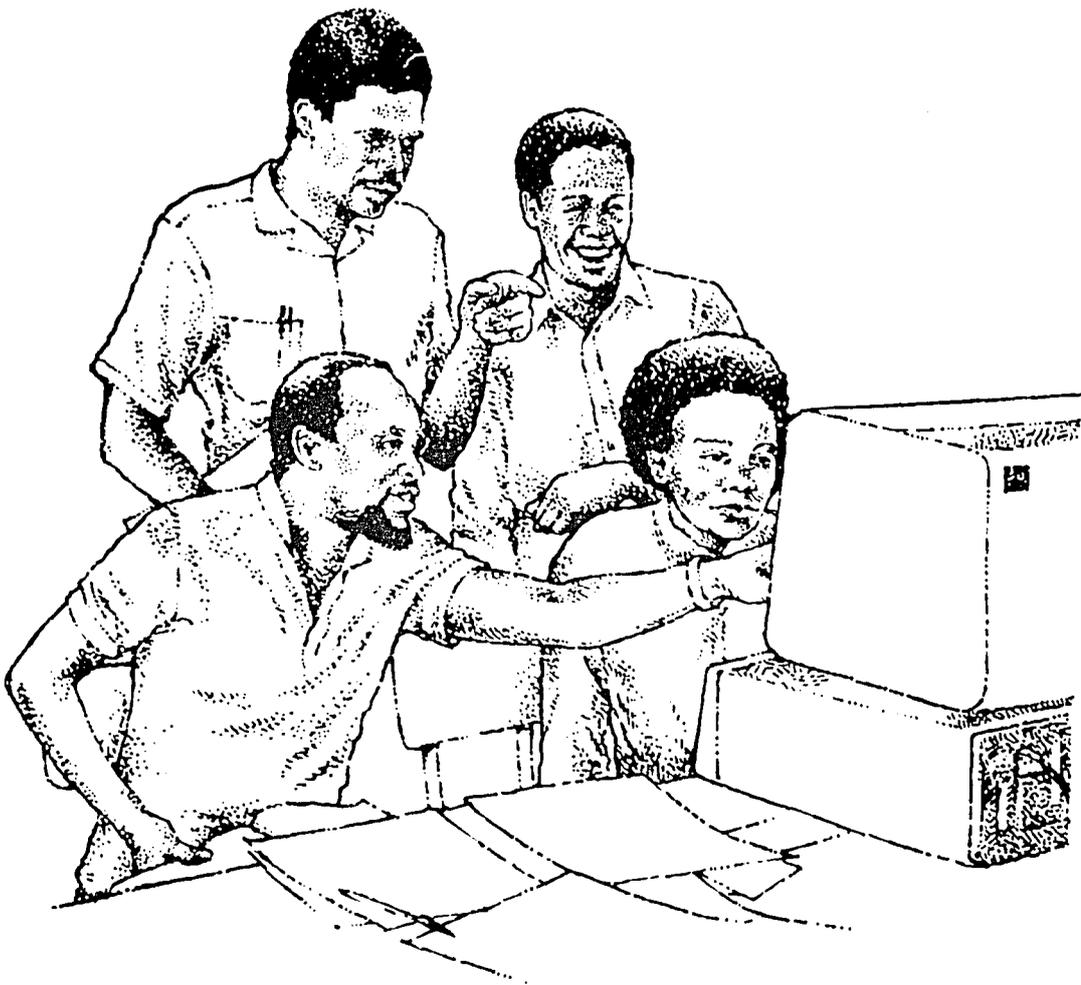
Constraints: *Education, Training, and Research Capacity*

Projects (13): **ALL**

From the beginning, all CRSP projects have included degree and non-degree training as part of their research program. Multidisciplinary training has been emphasized with a concerted effort to have a balance of females to males. In addition, the policy of joint U.S. and Host Country sharing of funds for project operations has strengthened institutional research capacity through the upgrading of physical facilities and the purchase of equipment where needed.

When the CRSP began, many national legume programs were suffering from neglect, lack of investment, and the predominance of expatriates. Ten

years later, through the CRSP partnerships, most of these national programs have matured substantially with a critical mass of their own professionals making major contributions to the international agricultural research community. Notable examples include the bean improvement programs in **BRAZIL** (one Ph.D., eight M.S.), **DOMINICAN REPUBLIC** (one Ph.D., eight M.S.), **MALAWI** (three Ph.D., two M.S.), **TANZANIA** (four Ph.D., four M.S.), and the food science cowpea program in **NIGERIA** (five Ph.D., 12 M.S.). Of all of the CRSP Host Country students who have completed graduate degrees, over 95 percent have returned home and are contributing to the legume program there.



TRAINING CONTRIBUTIONS AND GENDER RESPONSE

Training has been important in the CRSP and has been closely integrated with research objectives. The network which has grown out of these efforts is an exciting achievement bringing together women and men from many nations, ethnic groups, and language backgrounds. As these scientists take over increasingly responsible positions in their countries and maintain contact with one another across international boundaries, a vibrant mechanism for improving the availability of food is set in motion as is a strong force for international cooperation and peace.

In all, the CRSP has awarded 56 Ph.D., 97 M.S., and 66 B.S. degrees.¹ In addition, 899 persons have received non-degree training. Interestingly, over the years, of those having received graduate degrees (Ph.D. and M.S.), the distribution holds at about three-fifths male to two-fifths female even given strong CRSP efforts to identify female candidates for graduate level training. Among those from other developing countries (those not officially participating in the CRSP), the much greater imbalance between males and females undoubtedly reflects the characteristics of the pool, e.g., the smaller likelihood of female students coming to the U.S. without full support, looking for a sponsor.

<hr/> % Males and Females Who Have Received Ph.D. and M.S. Degrees <hr/>							
By Year	% Male U.S.	% Male HC	% Male Other	% Female U.S.	% Female HC	% Female Other	Total % M/F
3	19	30	16	19	13	3	65/35
5	24	21	15	13	22	5	60/40
8	21	27	15	16	16	5	63/37
10	17	26	16	16	18	7	60/40

 HC=Host Country

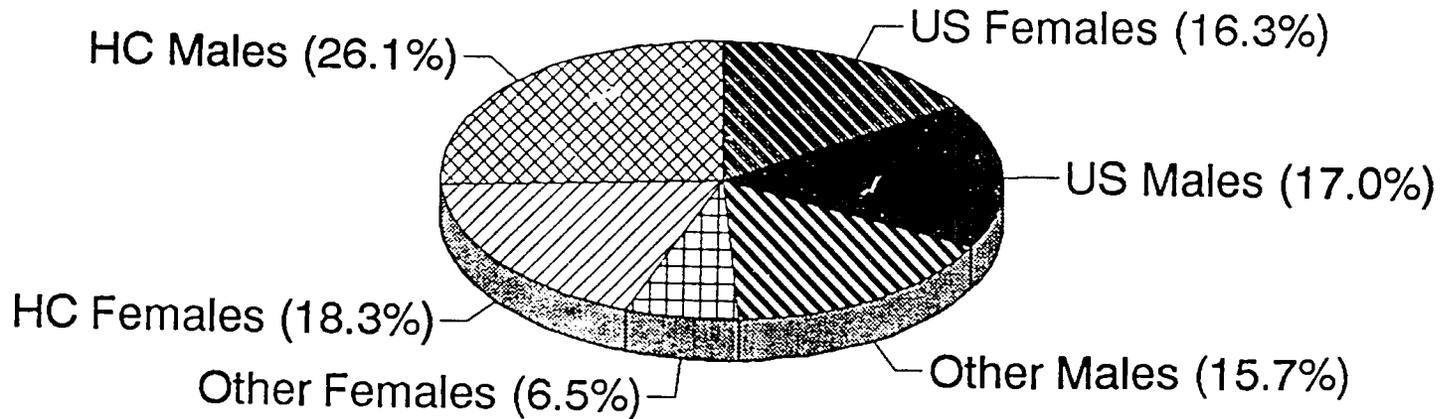
A recent survey of CRSP alumni, included in the *Training Report*, suggests the importance of CRSP training for the individuals involved as well as for the institutions from which they came. With a 51 percent survey return, the graduates reported being very positive about their CRSP training, especially in relation to the relevance of the content, the amount of content matter in their programs, and the specific skills learned. Most of the respondents received degrees in plant sciences, although a small number did study in other biological and social sciences.

¹Ten-Year Student Training Report, 1980-1990

BEAN/COWPEA CRSP

MS/PhD Degrees Completed, 9/30/1990

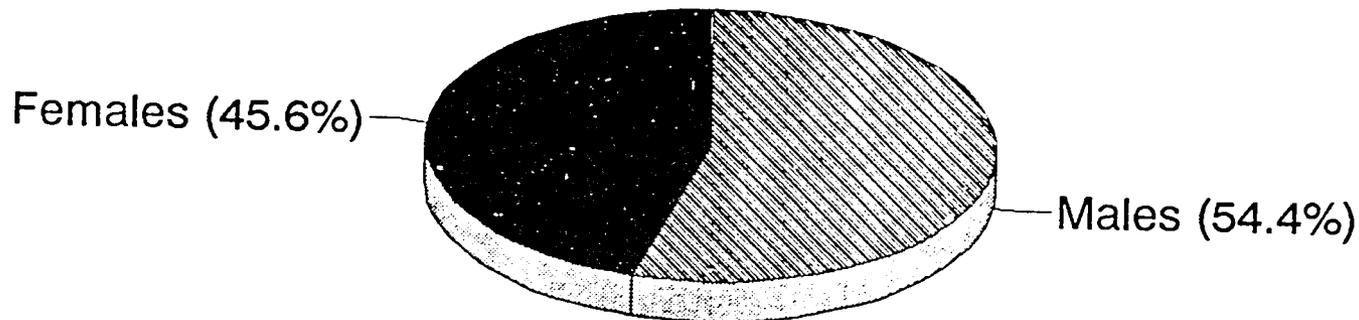
Gender Distribution (Total 153)



BEAN/COWPEA CRSP

MS/PhD Degrees in Progress 9/30/1990

Gender Distribution (Total 57)



Areas studied outside of their disciplines which the respondents rated especially high were statistics and computer science, which they indicated have been the added areas most relevant to their country's needs. A few even suggested work in these areas should be increased.

Of the skills acquired, most rated research/field/lab techniques as especially valuable. Those who had had contact with extension during their training were very pleased with this opportunity. Field trips and assistantships were the most highly rated practical experiences--most likely because these experiences, especially the assistantships, provided a context for working closely with their major professors. The importance of this opportunity is supported by the respondents in that nearly all reported continuing to maintain contact with their major professors. They also maintain contact with other CRSP alumni, further strengthening the international research network.



Training initiatives in the extension period are expected to increase. The importance of maintaining U.S. and Host Country young scientists in the pipeline has been repeatedly reinforced. The Bean/Cowpea CRSP considers this institution building and professional development function to be a critical part of its mission.

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Conclusions and Summary of Achievements

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CONCLUSIONS

The External Evaluation Panel charged by A.I.D. to annually evaluate the Bean/Cowpea CRSP has once again given this CRSP its highest rating. It is noted that over the ten years of its existence, this CRSP has established strong collaborative research projects with leading U.S. and Host Country researchers in Africa, Latin America, and the Caribbean. The research and training achievements from this teamwork have been impressive and form the foundation for the next phase of the research to be done.

Interest in "buying-in" to the CRSP on the part of non-participating USAID Missions has resulted in additional research efforts supported by non-core funds. These initiatives expand the research field, the germplasm base, and the cohort of scientists focused on CRSP objectives.

The Bean/Cowpea CRSP has reached a significant level of maturity. As a result of its growing role and contributions as well as those of the other CRSPs (Small Ruminant, Sorghum/Millet, Peanut, Soil Management, Pond Dynamics/Aquaculture, Fisheries Stock Assessment, and Nutrition), a CRSP Council was formed to facilitate the interaction and integration of research and training across commodity and topic foci. This greater integration of efforts will strengthen the network's contribution to sustainable agriculture in the next phase.

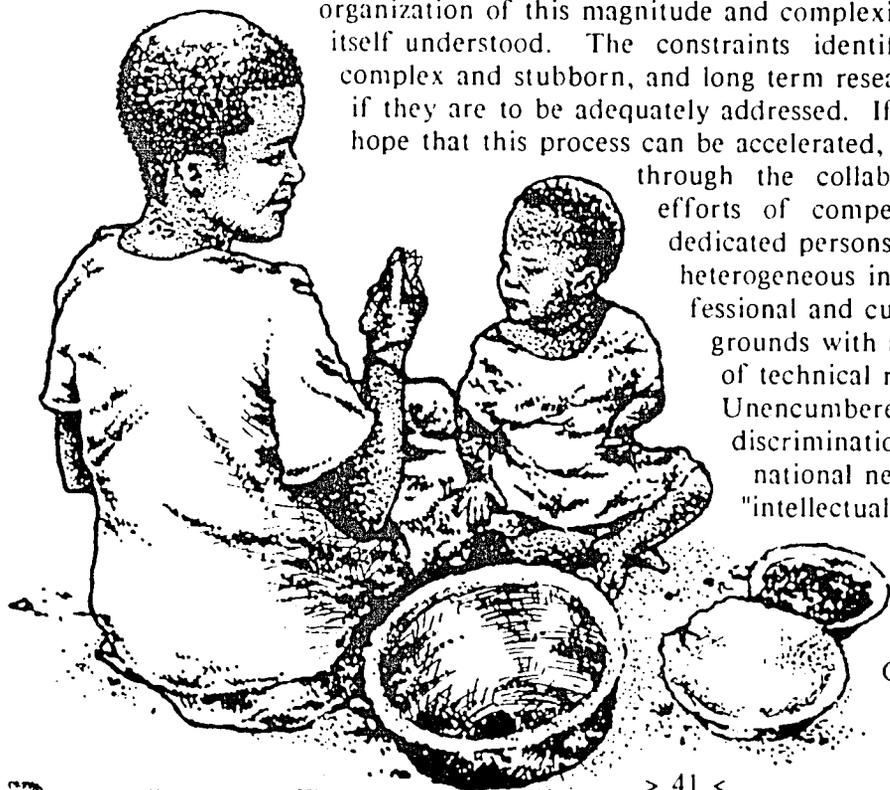
Slowly the real value of the resources represented by an organization of this magnitude and complexity is making itself understood. The constraints identified are complex and stubborn, and long term research is required if they are to be adequately addressed. If there is any hope that this process can be accelerated, it will be

through the collaborative efforts of competent, dedicated persons who are heterogeneous in their professional and cultural backgrounds with a wide range of technical resources.

Unencumbered by gender discrimination and national neglect, this

"intellectual germplasm" is the true

richness of the Bean/Cowpea CRSP.



SUMMARY OF ACHIEVEMENTS

CONTRIBUTIONS TO AGRICULTURE IN DEVELOPING COUNTRIES

1. Using CRSP research findings, led by the University of California-Riverside, cowpea production in Senegal in 1985 and 1986 generated an average gross-value-increase of approximately \$35,000,000 each year. The four-fold increase in production using California Blackeye #5 seed fed over a million people severely affected by the multi-year drought which had left granaries empty. Opportunities for U.S farmers and businesses resulted from the sale of this seed to Senegal which CRSP research had determined to be adapted to conditions there.
2. An economic impact study was conducted on the Senegal CRSP project (University of California-Riverside) covering the period from 1985-87. Emphasis was placed on the impact to farming practices and production in Senegal as well as the training of research scientists. The rate of return analysis of this project was 63 percent.

The major impacts of the Senegal CRSP project were:
 - a. General increased cowpea yields and yield stability for Senegalese farmers.
 - b. Preservation and enhancement of Senegalese cowpea germplasm.
 - c. Improvement in household food security in Senegal.
 - d. Strengthened Senegalese cowpea research capacity and increased international linkages.
3. The Cameroon/Purdue project found that exposing cowpeas to temperatures around 57°C for one hour, or 65° for a few minutes, killed the cowpea weevil larvae and pupal in the seed as well as adults living among the seeds. A solar heater was designed which was cheap and easy to build. This new solar disinfestation of cowpea stocks will have a dramatic impact on low-resource farmers in developing countries. This technology is also adaptable to beans as well as other crops with insect storage problems.
4. A non-race-specific, rust-resistant, leaf pubescence trait (hairiness) was found for beans by the Dominican Republic/University of Nebraska project. This type of resistance can be used everywhere in

the world and should be a durable type of resistance. The genetics of leaf pubescence was also determined. This should significantly reduce the use of dangerous and expensive chemicals.

5. Through the collaboration among scientists from the Dominican Republic, the University of Puerto Rico, and the University of Nebraska, the recent release of an improved bean cultivar, PC-50, is providing higher yields to farmers and better quality grain and nutrition to the consumer. Approximately 400 metric tons of seed were produced of PC-50 to meet the Dominican Republic's red mottled seed needs.
6. Using the most recent biotechnology procedures, four bean infecting geminiviruses have been cloned and sequenced by the University of Wisconsin scientists. Three bean golden mosaic geminiviral isolates (BGMV), thought to have the greatest genetic diversity, were from the Dominican Republic (BGMV-DR), Brazil (BGMV-BZ), and Guatemala (BGMV-GA). The other geminivirus (bean dwarf mosaic [BDMV]) was from Colombia. Each virus had a genome composed of two distinct DNA components.
7. Nucleic acid squash and dot blot hybridization techniques for BGMV screening were developed at the University of Wisconsin from the information above. A general geminivirus DNA probe and three isolate-specific DNA probes (BGMV-BZ, BGMV-DR/GA, and BDMV) were developed and are used in this technique.
8. Using the results of this work and new particle-gun technology, transgenic beans containing foreign genes have been developed for the first time ever. Working together, the Dominican Republic/University of Wisconsin project and a private research firm, Agracetus, Inc. are responsible for this achievement. The new technology producing this breakthrough promises to have a major impact on plant improvement research for many crops worldwide. With the introduction of resistance to BGMV, now in process, a major impact on this severe disease in beans in the Latin America/Caribbean region is expected.
9. Women in Development (WID) has played an important role in program achievements. Women in Agriculture Resource Guides have been produced for Cameroon, Guatemala, and Botswana and distributed widely to libraries, research programs and educational institutions. In addition, an annotated bibliography on Malawi was produced.

10. Cooperating with IITA and the University of Georgia, CRSP research identified a new high-yielding cowpea cultivar for Cameroon. Seed demand by Cameroon farmers for this cultivar went from 5 metric tons in 1984 to 47 metric tons in 1986. Yields doubled and quadrupled with the use of this variety and good agronomic practices.
11. In the Honduras/University of Puerto Rico project several small red bean lines were developed with resistance to all known strains of bean common mosaic virus. Anthracnose resistance was identified in the recently released variety "Catrachita" and in the breeding lines HND 43-40 and EAP 12-88.
12. Malawi/Michigan State University research has shown that farmers play a pivotal role in maintaining the genetic diversity in beans in Malawi. The study also described the importance of diversity in their cropping and household food strategies. The research helped to identify a bean breeding strategy, "component breeding," as a means of maintaining genetic diversity and meeting smallholder needs.
13. After extensive testing by the Mexico/Michigan State University project, twenty bean genotypes were identified which had good yield and drought tolerance. These selections were used as the base population for an extensive hybridization program to further increase the drought tolerance of the lines.
14. In Nigeria, technologies have been developed at the village level to produce stable cowpea flour. Working with the University of Georgia, and with support from AFRICARE, two village mills have been installed and brought into production. The mill products include cowpea meal, cereal, cowpea flour blends, and cowpea-based weaning foods.
15. A technique for drought resistance screening of cowpea genotypes for differences in rooting was developed by the Senegal/University of California-Riverside project. It uses a herbicide placed deep in the soil to detect the presence of deep roots. This method was then used to select cowpea genotypes with deep rooting ability.
16. The Senegal/University of California-Riverside project identified several heat-tolerant cowpea genotypes at the various stages of plant development including floral bud initiation and development, peduncle elongation and flowering, pod set, and embryo and seed coat development. This germplasm has been used in the breeding program. A potential new release has strong resistance to the seed-borne diseases bacterial blight and mosaic virus, partial resistance to the cowpea weevil, and a higher yield than the traditional varieties.

17. In Tanzania, an improved bean line (TMO 216) is in the process of being released by scientists working with Washington State University. Forty other advanced lines with multiple disease resistance are in advanced yield trials. Several are also being evaluated for farmer/consumer acceptance.
18. Five black bean germplasm lines with high biological nitrogen fixation capacity were released as breeding lines to breeders throughout the world by the Brazil/University of Wisconsin project.
19. Several different fungi have been identified by the Brazil/Boyce Thompson Institute project which have the potential of controlling some very important cowpea insects. *Metarhizium* and *Beauveria* have been shown to control the cowpea curculio. *Zoophthora* has been shown to control cowpea leafhoppers. Biological control technologies are being developed which can help reduce the use of poisonous pesticides.
20. Germplasm collection, evaluation, and preservation are very important throughout the CRSP. The Cameroon project has acquired 95 new accessions of *Vigna unguiculata* subspecies *dekindtiana*, 65 accessions of *V. luteola*, 18 of *V. oblongifolia*, 55 of *V. racemosa*, and 73 of *V. vexillata*. Several cowpea varieties were identified which possess good levels of pod resistance to the cowpea weevil. The Malawi project has collected and characterized hundreds of new accessions which were added to that country's already extensive collection. All of these materials are widely exchanged within the international research network.
21. Bean germplasm with improved disease resistance has been identified by the Dominican Republic/University of Nebraska project. Three Pompadour lines showed moderate levels of resistance to ashy stem blight. Several red mottled and black dry bean lines were developed with resistance to web blight and/or common bacterial blight. Lines tolerant to bean golden mosaic virus were also developed.
22. Several dry bean genotypes were identified by the INCAP/Washington State University project which take less time to cook. This characteristic is very important in many areas of the world that have a shortage in cooking fuels (firewood).

CONTRIBUTIONS TO AGRICULTURE IN THE UNITED STATES

1. Bean workers throughout the country have attested to the fact that virtually every U.S. bean program, public and private, has been strengthened through the research efforts of the Bean/Cowpea CRSP. The benefits include basic and applied information and new germplasm to buffer the serious consequences of past genetic erosion of bean and cowpea germplasm in the U.S.
2. Two snap bean germplasm lines with enhanced biological nitrogen fixation (BNF) capacity have been released to breeders in the U.S. by Wisconsin scientists. The incorporation of enhanced BNF capacity into new bean cultivars will reduce the application of high levels of nitrogen thus reducing some of our nitrate pollution of our groundwater. This reduces U.S farmers' costs \$15-20 per acre by reducing the input of chemical fertilizer, which also reduces groundwater nitrate pollution.
3. New bean cultivars from the incorporation of germplasm from several developing countries were released by CRSP scientists at Michigan State University and are being planted on over 80,000 acres per year. They give a 20-25 percent increase in yield. In a normal year, the increase can mean over 3.7 million extra dollars for Michigan growers (average yield per acre = 12 hundredweight; 22 percent increase per acre = 2.6 hundredweight; 80,000 acres x 2.6 hundredweight = 208,000 hundredweight increase x \$18/hundredweight = \$3,744,000).
4. The University of California-Riverside project has developed, with genetic contributions from Senegal cowpea lines, a potential new cowpea variety for California which has better heat tolerance than the current varieties. It also has excellent agronomic characteristics including resistance to fusarium wilt.
5. A new red kidney cultivar was released in New York based on CRSP work at Cornell University. It yields 20 percent more than the old cultivar, is a superior canning product, and is being planted on 2,000 acres per year. This can mean \$150,000/year for New York growers.
6. Eighty bean cultivars were evaluated for tolerance to low phosphorus levels in the Ecuador/University of Minnesota project. Several lines with apparent tolerance to low phosphorous were identified.

In addition, several strains of rhizobia with tolerance to soil acidity have been identified. These strains were shown to differ significantly from the average bean rhizobia.

7. The objective methods that were used by the University of Georgia to characterize the texture and structure of cowpea products correlated well with sensory measures. The response of U.S. consumers to akara, a traditional Nigerian snack, was positive, most favoring a ready-to-eat product with a sauce or dip. U.S. industry groups in the Southeast and California have expressed interest in akara's potential as a commercial food product.
8. Monoclonal antibodies are being used by the Washington State University-Prosser lab to identify and trace bean common mosaic virus strains. This is very important to prevent the spread of seed-borne virus diseases and is being used by the regulatory agencies of many states.
9. Cowpeas are a very drought-tolerant crop. However, there are differences between cowpea varieties in their ability to survive under drought conditions. University of California-Riverside studies have shown that some cowpea varieties have a better water-use efficiency. These efficient cultivars are identified by using a carbon isotope discrimination test.
10. A new large-seeded, bright white Great Northern dry bean has been released by CRSP researchers at the University of Nebraska. Named "Starlight," this cultivar is expected to give Nebraska a competitive edge in foreign markets where these traits are important.
11. New technologies for the development of transgenic plants have been developed. Working together, the University of Wisconsin and a private research firm, Agracetus, Inc., have evolved, for the first time, new genetically altered bean plants. The potential of this technology for U.S. agriculture far surpasses beans alone.
12. Procedures and criteria for assessing bean food quality have been developed by the INCAP/Washington State University project. Standardized protocols are being used by breeders in the U.S. This is especially important for the U.S. canning industry.

