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Global Plan and Progress Report

THE BEAN/COWPEA
COLLABORATIVE RESEARCH SUPPORT PROGRAM
(CRSP)

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PREFACE

The Bean/Cowpea Collaborative Research Support Program (CRSP) is a research and training partnership involving US Land-Grant universities, Host Country (HC) agricultural institutions in Africa and Latin America and the US Agency for International Development. HC and US scientists participating in the CRSP have made long-term investments in the relationships which are the foundation of the program. The investments are both professional and personal as, over the last five-plus 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.

In thoughtful discussions among these professionals, various points of view have been shared in attempts to identify research strategies which will contribute to human well-being throughout the world. From the array of national, cultural, ethnic, gender, class and disciplinary perspectives, their interactions have opened up new horizons for the development and application of evolving science and technology. The researchers, most of whom were wrestling with global issues independently long before coming together in the CRSP, have found the collaboration stimulating and have experienced new power in the expanded peer relationships. The international traffic of scholars conferring across participating countries highlights the mutual benefits of the relationships.

What has evolved from the investments? What are the features which unite the participants, strengthen the network and contribute to the success?

It is too trite to say the world is small. But it is indeed a fact that problems in even the smallest, most remote countries of the world can radiate their impact around the globe; e.g., official and unofficial acts of aggression, domestic influences on the international terms of trade, and the inevitable leveler of all forms of agriculture--the weather. No country can avoid being affected by the expanded use of chemicals and worldwide pollution or the social and political effects of so many severely stressed national economies. All of these issues demonstrate that the US too lacks immunity from the unemployment, poverty, hunger, drought, infestation and disease problems suffered by many other nations. In reality, the US is also a developing country which will benefit from a sharing of knowledge and resources. It too will benefit from the strengthening of national institutions around the world with which it can collaborate.

There are, in every society, people in whom critical aspects of their culture's knowledge have been invested. Some of these people are scientists and scholars. Others are lay people, frequently without formal education, who have received traditional wisdoms honed from generations of trial and error. Some of these men and women have a vision that, in an appropriate context, this knowledge can contribute to solving the pressing social and environmental problems of their time. As the world gets smaller, such persons search for ways to seek out one another as the task is clearly beyond the capacity of a few. World hunger and malnutrition are the focus of CRSP people who have coalesced around the two commodities beans and cowpeas. In so doing, they have built a network which pools their respective knowledge and resources for increasing the availability of these important protein-rich foods. This document describes the extent of their efforts.

The introduction presents basic information on the CRSP. It is followed by the updated CRSP Global Plan on which the program is based. The third section discusses briefly the status of each of the major constraints to the availability of beans and cowpeas and presents what the CRSP has accomplished thus far toward the alleviation of those constraints. A list of individual achievements is included at the end of that section. Finally, a summary statement and brief financial report conclude the document.

The impact from this first 5.6 years is just beginning. It is likely that the network established here will far outlive the CRSP because CRSP people, who may differ in so many outwardly appearing ways, have acknowledged a basic vulnerability. This year, for example, record rains destroyed over 50 percent of the bean crop in Michigan, the leading dry bean producing state in the US. Sophisticated production technology was of little use. It is clear that none of us is without risks or, likewise, without resources. In the long run, we are united by both an understanding of our ultimate dependence on nature and a collective appreciation of our need for one another in meeting its challenge.

Pat Barnes-McConnell
Director

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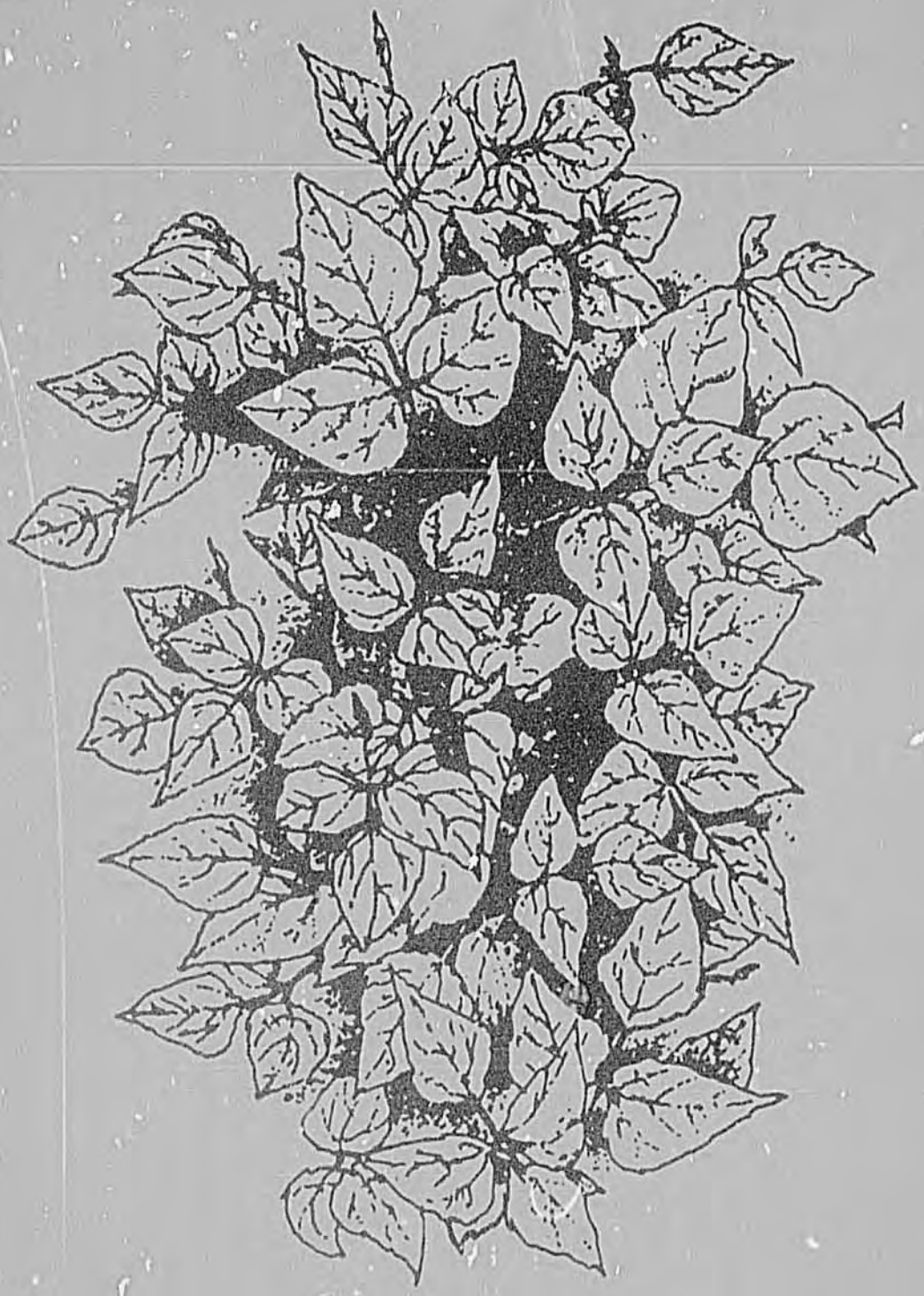

INTRODUCTION

Following a two-year planning period, the Bean/Cowpea CRSP was implemented in October 1980 with funds from the US Agency for International Development (AID) as authorized by the Board for International Food and Agricultural Development (BIFAD) under Title XII of the Foreign Assistance Act designated "Famine Prevention and Freedom from Hunger." The original Bean/Cowpea CRSP grant was in effect for five years and seven months, after which a new extension grant was awarded to continue the work. This document is a report of progress during that original time period.

Organized to bring together the resources of Host Country (HC) and US research institutions, the CRSP was concerned with addressing critical problems inhibiting bean and cowpea production and consumption, especially in those areas of the world where these foods are important in human diets. It was understood that the achievements would also be useful for US bean and cowpea growers. The international scientific community that evolved has enjoyed a strengthened bean/cowpea research and training capacity as a result of these efforts.

During the original grant, the CRSP worked with eight countries in Africa (Botswana,* Cameroon,* Kenya, Malawi,* Nigeria,* Senegal,* Tanzania* and Uganda) and six countries in Latin America (Brazil,* Dominican Republic,* Ecuador, Guatemala,* Honduras* and Mexico*). These efforts, encompassing joint research as well as training of students from the US and developing countries, evolved from a comprehensive global plan which was developed during the planning years. The Global Plan (presented in its entirety in the following section), periodically updated and modified as appropriate, is the framework which has guided the evolution of the CRSP in line with international bean and cowpea research needs and resources.

Similar to the movement of several decades ago which established the network of International Agricultural Research Centers (IARCs), the CRSP context was introduced into an evolving international agricultural research and development system as a new and needed component. According to extensive external reviews, it is a cost-effective model, a model that can perform a critical international role outside of the mandates and capabilities of other international agricultural research organizations. Critical among the model's characteristics are:

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*Countries with ongoing Bean/Cowpea CRSP projects

1. The tremendous size of the resource base represented by the array of participating US universities, whose resources include the professional expertise, the related ongoing teaching and research programs, the extensive research facilities and the administrative support structure of the US Land-Grant system;

2. The diversity of professional disciplines available to contribute to the problem-solving efforts;

3. The working partnerships of committed colleagues professionally rewarded for collaborating across national boundaries with other participating scientists.

Thus, the CRSP complements and supplements IARCs and other public and private research organizations by broadening and deepening the overall research support base and the linkages which reinforce the international agricultural research system. Performing in a highly acceptable, interactive mode for agricultural development, the CRSP brings the diverse, largely untapped resources of US centers of excellence into collaborative international research and training activities. Through these efforts, the CRSP is extending the worldwide network of institutions and individuals cooperating in important bean- and cowpea-related research. More broadly over time, it helps fashion and strengthen enduring linkages throughout the international agricultural research and development system.

The following example highlights the importance of the contributions made by the CRSP in the establishment of linkages among national programs, international research organizations and the US agricultural research system including USDA and private research institutes. The head of the bean program at CIAT has recently spoken of the mutually enhancing features of the Bean/Cowpea CRSP and CIAT. Three of his points regarding the CRSP role are especially illustrative:

1. CRSP basic research is making important contributions to the ability of CIAT to advance its program. The viral work of the Washington State University/Tanzania project, the BNF work of the University of Wisconsin/Brazil project, the work on biological control of insects of the Boyce Thompson Institute/Brazil project and the heat and drought work of the University of California Riverside/Senegal project are all examples of CRSP research whose output is being incorporated into international center research.

2. CRSP contributions to national programs strengthen CIAT's research effectiveness especially where the national programs

were weak in terms of numbers of professional staff, infrastructure and operational research capacity. For example, in the Dominican Republic where the CRSP has trained researchers, added critical infrastructure and provided support for ongoing research activity, more CIAT materials are being tested, the work is superior and the materials coming out of that research are enriched by the inclusion of other lines developed through CRSP research as well as those from CIAT. Programs strengthened in this way are more receptive to participation with CIAT research and the participants are more professionally confident. The materials generated are much improved and transferable to other CIAT efforts. Thus, CRSP-strengthened national programs have become a reinforcing and increasingly dynamic link in the flow of professional interactions and subsequent research achievements of the total agricultural research system. This is in contrast to situations which often existed before the CRSP, when many national programs were beleaguered and work had begun to bog down.

3. CRSP training for HC students not only adds to the critical mass of professionals in national programs, those students also (a) work with specialists at the universities on stubborn research problems which are a bottleneck in agricultural development and (b) themselves move easily among the national programs, CRSP institutions and the IARCs, strengthening these linkages in the process of their training. Thus, not only are they well-trained, but they are also doing research highly relevant to the national programs and the IARCs where research progress had been blocked. In addition, they reinforce the inter-program linkages which will be mutually beneficial to all parties. The CIAT bean program leader cited the MSU/ Malawi project in regard to this point. As CIAT moves more substantively into Africa, they see as one of their biggest challenges the vast genetic heterogeneity of bean mixtures common throughout certain regions of that continent. Because Western research has traditionally been based on pure lines, he feels the products of the MSU/Malawi project's research (genetic, agronomic and socio-cultural) will be an absolute must--the baseline data and understanding of the system are all requisites for CIAT's work being initiated in that region. Students from Malawi continue to be trained in many different but related disciplines for future work with the national bean program.

Reinforcing this position, the CRSP External Evaluation Panel reports there is good evidence that:

1. The CRSP is a mechanism which supports better equity within research teams engaged in development activity. The model develops a pattern of interaction which is not hierarchical but collegial in nature, providing an important avenue for the active participation of HC professionals in the development process.

2. The CRSP provides one vehicle for the contribution of science and technology to development as a necessary but insufficient partner along with such factors as government-pricing policy and extension. As such, the CRSP is an important component of the US bilateral assistance program contributing to the total AID effort to alleviate world hunger.

3. The CRSP has shown itself to be a rapid method of generating technology fitting the specific needs of Host Countries. It is an effective way to transfer and build greater capacity to solve problems and generate new knowledge.

4. The actual research, involving the collaboration of scientists cross-nationally, and the training of new professionals effectively support the institution-building components of this CRSP. Both within the African and Latin American regions and across regional lines, professional networks are evolving which strengthen the institutional capacities of participating organizations.

5. The CRSP training resources effectively utilize a variety of training modes (degree/non-degree, formal/informal, domestic/ international) directly geared and linked to the needs of the countries. Further, HC students have the opportunity to study in the US with US professors who are working on behalf of the students' own countries and frequently are working intermittently in these countries.

6. The CRSP has attracted a remarkable number of US and HC scientists. In the US it has strengthened the interest and capability of US institutions to understand and participate in development.

7. The CRSP supports attention to the role of women in agriculture and the involvement of women in its projects. It has improved the attitude of male professionals toward working with professional women. Attention is being paid to efforts to advance women throughout the system.

8. The CRSP, in evolving a problem-solving network, has developed a community of US and HC scientists for scientific

and technological development which should prove itself productive over the long term.

In addition, there are specific contributions to US agriculture from this model which were noted by the EEP.

1. Bean/Cowpea CRSP projects/activities are concentrated largely on producing superior bean and cowpea cultivars and supporting production technologies (e.g., enhanced N-fixation). Predictably, these cultivars and technologies will contribute directly and indirectly to the development of superior cultivars and production technologies for the United States.

2. An important related activity of most CRSP projects is the collecting, describing, cataloguing and conserving of bean and cowpea germplasm. These irreplaceable genetic resources will become available over time to the United States and to other bean- and cowpea-growing nations and, therefore, will increase the range and diversity of genetic stocks available for improvement programs.

3. New resources and procedures for the control of pests and diseases in bean and cowpea production are emerging, i.e., insect pathogens, antiserum procedures to assess virus strains in plant material. These new technologies will not only support legume improvement programs in the US and other legume-producing countries, but they will also expedite the ability of nations to utilize one another's plant material in adaptation trials and improvement programs across national boundaries.

4. The Bean/Cowpea CRSP has a limited, but highly important, focus on improving the human nutritional characteristics of beans and cowpeas through breeding, processing and food science programs. This focus can be expected to have a salutory impact on bean/cowpea production research, as well as home and commercial processing which ultimately will contribute to United States industrial interests.

Thus, as an organized and comprehensive set of research projects, the CRSP has become an important part of the agricultural system. Clarification of its mandate and presentation of its subsequent accomplishments are given in the sections which follow.

The Global Plan of the Bean/Cowpea CRSP

THE GLOBAL PLAN OF THE BEAN/COWPEA CRSP

INTRODUCTION

PROGRAM GOAL

The Bean/Cowpea CRSP makes available to the international agricultural research and development system a new avenue to the US agricultural research network. In so doing, this CRSP is expected to make 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 commodities.

The original grant document, operational for the first 5.6 years, 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 and increasing availability of low-cost nutritious foodstuffs in the marketplace for the rural and urban poor in LDCs.

PROGRAM PURPOSE

The original 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 US-LDC collaborative effort of research and training in bean- and cowpea-related areas.

THE GLOBAL PLAN

The CRSP is to stimulate and support commodity-related collaborative research among AID, the US Land-Grant university community (with limited contributions from the US Department of Agriculture), private institutes, Host Country institutions and identified International Agricultural Research Centers. These aggressive collaborative efforts are to focus on the identified persistent constraints to bean and cowpea production and utilization. Thus, this CRSP Global Plan to increase bean and cowpea availability presents an organized set of research efforts. They are designed to address the specific constraints in representative agro-ecological areas of the world where beans and cowpeas are

grown. The elements of the plan include the bean and cowpea constraints, the groups to be served, the countries chosen for collaboration, the participating US institutions and the guidelines and policies which provide direction for the program. The network of scientists established by this CRSP will make accessible, to interested programs in the US and HCs, expertise for problem-solving throughout the developing world.

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 US.

CONSTRAINT ELEMENTS

Through visits to Host Countries, communications with official HC representatives and review of appropriate literature, the major constraints to bean and cowpea availability were identified. This information was documented in the resulting state-of-the-art publication (Adams, M. W. 1984. Beans--Cowpeas: Production Constraints and National Programs. East Lansing, MI: MSU, Bean/Cowpea CRSP Management Office) and became the basis for the development of projects in representative regions.

The constraints identified are as follow:

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

SERVICE ELEMENTS

Emphasis is placed on servicing the needs of small-scale farmers, especially women who have the major responsibility for family food production and processing. Contributions from the social sciences as well as the biological sciences are important in reaching this population. US growers will also benefit.

GEOGRAPHIC ELEMENT

Because sensitivity to daylength, temperature and rainfall patterns are important in the adaptation of beans and cowpeas, countries providing a range of agro-ecological conditions were chosen for the research. The Host Countries currently participating in this CRSP are:

AFRICA		LATIN AMERICA	
Botswana	Nigeria	Brazil	Honduras
Cameroon	Senegal	Dominican Republic	Mexico
Malawi	Tanzania	Guatemala	

Collaborating with these nations are the following US institutions:

Boyce Thompson Institute, Ithaca, New York
Colorado State University,* Fort Collins, Colorado
Cornell University,* Ithaca, New York
Kansas State University, Manhattan, Kansas
Michigan State University,* East Lansing, Michigan
University of California,* Riverside, California
University of Georgia,* Athens, Georgia
University of Illinois, Urbana, Illinois
University of Minnesota, St. Paul, Minnesota
University of Nebraska,* Lincoln, Nebraska
University of Puerto Rico,* Mayagüez, Puerto Rico
University of Wisconsin,* Madison, Wisconsin
Washington State University,* Pullman, Washington

*Lead Institutions

PROJECT ELEMENTS

The projects are organized to provide research on the constraints in the countries representative of where these constraints are important and at locations where resources necessary for the collaboration exist. Each project is organized under the management of a US lead institution with a US Principal Investigator (PI) to lead the conduct of the joint research in the constraint area in collaboration with a Host Country PI. The current projects of the CRSP are as follow:*

Title of Project	Host Country	US PI/HC PI
Development of Integrated Cowpea Production Systems in Semiarid Botswana	Botswana	Jack deMooy/ David Gollifer
Insect Pathogens in Cowpea Pest Management Systems for Developing Nations	Brazil	Don Roberts/ Bonifacio Magalhaes
Identification of Superior Bean-Rhizobia Combinations for Utilization in Cropping Systems Suitable to Small Farms in Brazil	Brazil	Fred Bliss/ Ricardo Araujo
Pest Management Strategies for Optimizing Cowpea Yields in Cameroon	Cameroon	Richard Chalfant/ Zachee Boli
Biology, Epidemiology, Genetics and Breeding for Resistance to Bacterial and Rust Pathogens of Beans (*Phaseolus vulgaris* L.)	Dominican Republic	Dermot Coyne/ Freddy Saladin
Agronomic, Sociological and Genetic Aspects of Bean Yield and Adaptation	Guatemala	Don Wallace/ Porfirio Masaya
Improvement of Bean Production in Honduras through Breeding for Multiple Disease Resistance	Honduras	Jim Beaver/ Silvio Zuluaga

*Title as approved for extension

Improved Biological Utilization and Acceptability of Dry Beans	INCAP	Barry Swanson/ Ricardo Bressani
Genetic, Agronomic and Socio-Cultural Analysis of Diversity among Bean Landraces in Malawi	Malawi	Wayne Adams/ Wilson Msuku
Improving Resistance to Environmental Stress in Beans through Genetic Selection for Carbohydrate Partitioning, Water Use Efficiency and Efficiency of Biological Nitrogen Fixation	Mexico	Wayne Adams/ Rogelio Lepiz
Appropriate Technology for Cowpea Preservation and Processing and a Study of Its Socio-Economic Impact on Rural Populations in Nigeria	Nigeria	Kay McWatters/ Dickson Nnanyelugo
A Program to Develop Improved Cowpea Cultivars, Management Methods and Storage Practices for Semiarid Zones	Senegal	Tony Hall/ M'baye Ndoye
Breeding Beans (*Phaseolus vulgaris* L.) for Disease, Insect and Stress Resistance and Determination of Socio-Economic Impact on Smallholder Farm Families	Tanzania	Matt Silbernagel/ James Teri

STRUCTURAL ELEMENTS

To insure productive collaboration within the CRSP, projects are to be organized:

1. To be individual but structurally integrated in order to make the maximum research contribution to increasing the availability of beans and cowpeas;

2. To emphasize within projects multidisciplinary research integrating production and non-production issues;

3. To focus on research in traditional settings;

4. To build strong and collegial professional relationships among the HC and US researchers in each project;

5. To establish an international network of bean and cowpea researchers which will enhance communication linkages;

6. To facilitate the dissemination of appropriate technologies throughout the world;

7. To make financial resources available for both HC and US research activity;

8. To contribute to the strengthening of HC institutions through the enhancement of facilities and equipment needed to support that research;

9. To contribute to the strengthening of HC institutions through a significant level of graduate and undergraduate study, short-term courses, conferences and workshops;

10. To strengthen the role of women in agricultural research, production, marketing, processing and food preparation because of their primary role in the production of beans and cowpeas in many developing countries;

11. To be alert to mechanisms for information dissemination; and

12. To provide an opportunity for private sector participation in research activity and in the dissemination of project results.

ARTICLES OF THE GLOBAL PLAN

Through the collaborative project activity, HC as well as US 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 US/HC teams are clear.

1. We must address, collaboratively with HC 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 more productive and more stable production systems. The evolving systems must maintain 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 and phosphorous utilization. In order to escape the tyranny of the spiralling costs of these 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 by supportive methods of food technology.

6. We must promote the creation or operation of seed multiplication programs in order to reach the small-scale 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.

7. We must work to overcome or minimize the problems 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.

8. We must help evolve methods of storage and food preparation that conserve the full value of the dry grains without insect depredation 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 as food.

9. We must be cognizant of the interacting and sometimes contradictory results of various agronomic interventions. We must, therefore, carry out production/consumption-oriented research with socio-economic analyses to assess the acceptability and agro-economic 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 and men in developing countries as they affect production and consumption of beans and 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 extension work with beans and cowpeas.

13. We must facilitate the development of collaborative relationships, not only between US and HC scientists, but cross-nationally among HC scientists themselves and among US scientists as well.

CONCLUSION

While the constraints identified in this Global Plan are important country-specific issues, they exist worldwide wherever beans and cowpeas are grown and utilized. By distributing research attention to these constraints across the agro-ecological 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 research collaboration has demonstrated that there is as much specifically for the US to learn and gain from the traditional settings as there is for modern research to contribute in return. Through these partnerships the CRSP supports regional contributions which strengthen the total international agricultural research community. This Global Plan guides the evolution of the CRSP and provides the basis for its research and training activities.

PROFILE OF GLOBAL PLAN
BEAN/COWPEA CRSP

1986

Primary research attention: P
Secondary research attention: S

	BEANS								COWPEAS				
	BRZ UWI	DR UNL	GUAT COR	HON UPR	INCP WSU	MAL MSU	MEX MSU	TNZ WSU	BOT CSU	BRZ BTI	CAM UGA	NIG UGA	SEN UCR
1. Limitations due to insects								P		P	P		S
2. Limitations due to disease	P	P		P		S		P	S				S
3. Plant response limitations (genetics and breeding)	P	S		S		P	P						P
4. Limitations of the physical environment			P				P	S	P				P
5. Production-consumption economics, farming systems						P		P	P				
6. Nutrition, food preparation, health and storage					P	S		S			P	P	
7. Education, training and research capability	P	P	P	P	P	P	P	P	P	P	P	P	P

BEAN/COWPEA CRSP
GLOBAL RESEARCH PLAN
1986

NIGERIA

Cowpea processing and preservation

TANZANIA

Disease/insect resistant beans; socio-economic impact on small-scale farming

CAMEROON

Cowpea pest management strategies for small-scale farmers

MALAWI

Genetic, agronomic and socio-cultural analysis of bean landraces

SENEGAL

Cowpea varietal improvement for production and utilization in semiarid zones

IITA

Collaboration and interaction with CRSP cowpea programs

BOTSWANA

Cowpea farming systems research and variety evaluation in semiarid areas

BRAZIL

1. N-use efficiency in bean production and multiple resistance screening;
2. Cowpea insect pathogens

CIAT

Collaboration and interaction with CRSP bean programs

DOMINICAN REPUBLIC

Introgression of disease-resistant germplasm into adapted bean cultivars

GUATEMALA

Agronomic, sociological and genetic aspects of bean yield and adaptation

HONDURAS

Disease resistant cultivars for increased bean production

MEXICO

Bean plant responses to stress and N-fixation

INCAP

Cooking time and protein digestibility of beans

2085C:skb:062486

Program Goal	Objectively Verifiable Indicators
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.

Purpose	Objectively Verifiable Indicators
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.

LOG FRAME

Verifiers	Assumptions
Annual reports and positive TC/EEP reviews.	Food and nutrition problems in the developing nations can be solved in part through research.
Increased overall size of national program research team with greater multidisciplinary competence and HC investment in the project.	Collaboration between US and HC can be of mutual benefit.
Adaptation of findings by external agents: farmers, IARCs, extension agents, commercial interests.	Achievement from this program can reach the rural and urban poor.
Increased male and especially female CRSP graduates in the professional pipeline.	Achievements of this program can contribute to development in ways which do not increase the marginalization of women and their families.

Verifiers	Assumptions
Smooth management with good communication with MO.	HC will maintain interest in the commodity and in CRSP participation.
US/HC quarterly and annual reports.	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.
Formal commitment of participants.	Necessary basic equipment, facilities and supplies will be available or acquirable within reasonable time frame.
Consistent pattern of student training established.	There is a sufficiently large pool of students from which to draw for advanced training at least at the secondary school graduate level.
Documentation of secondary data.	
Primary data analyses available in reports and publications.	
HC contributions to CRSP documented in each year's budget analysis.	

Outputs	Objectively Verifiable Indicators
Stronger, better quality yields possible under identified constraints.	Yield increase under an array of stressful conditions to which developed cultivars are resistant or tolerant.
Greater understanding by US and HC collaborators of the socio-cultural and the agricultural environment.	Multidisciplinary research generated.
Products of research packaged appropriately for consumer use.	Informational materials available.
Information dissemination for a variety of audiences.	Interest of wider international and national research and development community in products.
Production and utilization research findings useful for the wider research community.	Better health among those making use of project outputs.
Many male and female graduates of training programs.	Male and especially female graduates returning to HC research institutions.
	Increased body of knowledge of constraints to greater bean and cowpea production.

Inputs	Objectively Verifiable Indicators
Necessary long-term/short-term personnel from HC/US institutions who can communicate with each other.	Annual allocation from AID.
Financial contributions from AID and US and HC institutions.	CRSP funds flowing on a regular basis to US and HC research teams.
Management support from MO, US and HC institution administrations.	Annual plan of work and budget document with US/HC contributions.
Equipment such as vehicles, lab, field and office equipment.	Active backstopping by administrators of US institutions with effective levels of communication.
Facilities and supplies for HC/US teams.	Frequent and regular communication among AID, MO, US and HC.
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).

LOG FRAME (CON'T)

Verifiers	Assumptions
Yield data from local and national census and scientific reports of research findings. Reports of projects incorporate and integrate socio-cultural with agricultural information. Materials acknowledged as received by many groups and increased consumer demand. Requests from professional community for information and research products increased. Articles published and seminars presented. Site visits. CRSP graduates identified in HC research positions. Increased numbers of male and female students continually in short-term and long-term training. Publications, presentations.	There exists in the HC at least a skeletal infrastructure for information dissemination. 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.

Verifiers	Assumptions
Increase in communications initiated by participants with one another. Review of annual documents by TC and BOD. AID letter of credit authorizing funds. Regular reimbursement requests with quarterly reports. Letters, phone calls and other expressions of interest and problem-solving support from US administrators. AID approvals to purchase indicated equipment received. Site visits. Meetings and other forms of communication with external groups.	AID will generate necessary approvals in timely fashion. AID will have funds available for use by the CRSP. All parties making input will continue to feel the mutual benefits worth the investments.

Progress Report

PROGRESS REPORT

As presented in the Global Plan, seven constraint areas severely restrict the ability of nations to make available needed amounts of beans and cowpeas. At the end of the original grant period, US and HC project leaders from the CRSP came together to assess (1) their progress in each of these constraint areas, (2) current research activities and (3) selected achievements to date. A comprehensive listing of the significant research and training accomplishments is included at the end of this section.

REPORT BY CONSTRAINT AREA

I. LIMITATIONS DUE TO INSECTS

Insect pests cause major losses of beans and cowpeas throughout the world and are often responsible for crop losses ranging from 30 to 100 percent. The plants are vulnerable to pest attack from the seedling stage to harvest as well as in storage. Traditionally, beans and cowpeas have been high-risk crops with low yields at the small-scale farm level. To reduce insect damage, there is a need to develop integrated pest management strategies utilizing insect resistant cultivars and inexpensive, as well as safe, pest control methods which can be adopted by small-scale farmers.

The major insect pests of beans and cowpeas are leaf hoppers, leaf beetles, cowpea curculio, bean fly, aphids, thrips, legume pod borers, pod-sucking bugs and bruchid storage beetles.

The US and developing country entomologists in the CRSP are collaborating on the following activities:

1. Evaluating germplasm for insect resistance.

2. Developing integrated pest management systems to control various insects.

3. Collecting and identifying insect pathogens to control insect pests.

4. Breeding insect-resistant cultivars for small-scale farmers.

5. Identifying storage techniques to control storage insects.

The CRSP projects with a major commitment to insect-related activities include:

1. "Insect Pathogens in Cowpea Pest Management Systems for Developing Nations"

   Boyce Thompson Institute/Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA](Brazil)

2. "Pest Management Strategies for Optimizing Cowpea Yields in Cameroon"

   University of Georgia/Institut de Recherché Agronomique [IRA](Cameroon)

SELECTED ACHIEVEMENTS:

1. Approximately 200 strains of insect pathogenic fungi have been collected and identified for biological insect control. These pathogenic fungi are being tested for the control of several major cowpea insects.

2. Three bean cultivars were identified with resistance to the bean fly, Ophiomyia phaseoli. These lines are being incorporated into the breeding programs in Tanzania and CIAT.

3. In the Cameroon, the CRSP worked with the national program to identify a high-yielding cultivar, TVX 3236. Seed demand for TVX 3236 has gone from five tons in 1984 to forty-seven tons in 1986. With the pest management systems introduced by the CRSP, farmers can expect average yields of 600-1,200 kilograms per hectare compared with 300 kilograms without the improved system.

4. Four cowpea cultivars were identified that exhibited an antibiosis resistance to the cowpea aphid. It was also shown that aphid-resistant lines from IITA were not resistant to the Georgia population of the cowpea aphid, demonstrating that breeding strategies need to consider biotype differences in their programs.

II. LIMITATIONS DUE TO DISEASES

Diseases are among the production constraints most often cited as problems by national bean and cowpea research programs and regional and international research centers. Major bean diseases include rust, common bacterial blight, anthracnose, bean common mosaic virus, bean golden mosaic virus, angular leaf spot, web blight and ashy stem blight. Important cowpea diseases include bacterial blight, ashy stem blight and several viruses. Disease control in beans and cowpeas is very important in stabilizing and/or increasing yields. Many of the diseases such as bean golden mosaic virus, anthracnose and rust are capable of causing significant losses. Diseases not only cause direct damage to the leaves and grain but this damage, which occurs in both field and storage, also affects nutritional quality. Management practices are important in the control of these diseases. However, disease control strategies used by small-scale farmers are influenced heavily by economic and technical constraints. Additionally, strategies to control the disease vector, e.g., the use of pesticides, are often undesirable for environmental reasons.

Due to the dynamic nature of pathogens, many of the diseases need to be continually monitored. Research on the pathogens confined to temperate regions is often of only limited use in a tropical context where they are usually the most active.

Research collaboration between the US and developing country institutions has been an especially successful model in addressing these constraints. The CRSP projects concerned with disease constraints are working in the following areas:

1. Epidemiology of pathogens.

2. Variability of pathogens.

3. Reliable techniques for the selective isolation and identification of tropical pathogens.

4. Integrated disease control methods for small-scale farmers.

5. Disease resistant cultivars for small-scale farmers.

6. Methods for identifying multiple disease resistance.

7. Strategies for deployment of research findings for small farms.

The CRSP projects with a major commitment to addressing disease constraints include:

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

   University of Nebraska-Lincoln/Secretaría de Estado de Agricultura [SEA](Dominican Republic)

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

   University of Puerto Rico/Escuela Agrícola Panamericana [EAP](Honduras)

3. "Breeding Beans (Phaseolus vulgaris L.) for Disease, Insect and Stress Resistance and Determination of Socio-Economic Impact on Smallholder Farm Families"

   Washington State University/Sokoine University of Agriculture [SUA](Tanzania)

SELECTED ACHIEVEMENTS:

1. The bean common mosaic virus antisera and serodetection protocols developed at Washington State University are being used to insure farmers of disease-free seed as well as to control the spread of bean common mosaic virus to new regions, including the US. This methodology is rapid and inexpensive.

2. The University of Nebraska/Dominican Republic project determined the inheritance of resistance to common blight and rust. Researchers found that the reaction of the leaves and pods to common blight was inherited quantitatively and that different genes controlled the resistance reaction in different plant parts.

3. The University of Wisconsin, working with Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA] in Brazil, has developed inoculation techniques for the sequential inoculation under field conditions with four major bean diseases (rust, common blight, angular leaf spot and anthracnose). Injuring bean plants via a sandblast immediately before inoculation with the common blight pathogen greatly improved infection levels.

4. The University of Puerto Rico, in cooperation with researchers in the Dominican Republic and Honduras, has developed bean cultivars with multiple disease resistance. Through their efforts, germplasm with disease resistance has also been identified and released for plant breeders throughout the world.

III. PLANT RESPONSE LIMITATIONS

The responses of beans and cowpeas to various environmental and soil constraints are important factors in their development. The CRSP has identified two areas which significantly influence the growth and development of these crops. These are nitrogen and population structure in landraces.

1. Nitrogen is a major nutrient constraint in bean and cowpea production throughout the world. For most farmers, nitrogen fertilizer is limited in supply and is expensive. Economic return of nitrogen fertilizer is very uncertain where other important production constraints exist. Inoculation with nitrogen-fixing bacteria, rhizobium, has been utilized as a low-cost nitrogen substitute but commonly fails to meet the plant's requirement for nitrogen; thus, yields suffer. The reasons for this failure are complex but include competition from native soil rhizobium, poor quality inoculants, non-responsive host cultivars and disease constraints.

2. Landraces represent repositories of genetic diversity. They are the source from which particular traits are chosen and incorporated into improved cultivars. It is not clear, however, whether breeders should attempt "pure line" breeding or aim for improved landraces per se. In developing country situations where certified seed of beans and cowpeas is rarely available, new cultivars can become physically mixed and, over time, mutations and outcrossings can accumulate great variability. Landraces also change over time. Such genetic drift must be evaluated if sound breeding strategies are to be developed.

CRSP researchers are conducting the following types of research efforts:

1. Developing cultivars with increased biological nitrogen-fixation capacity.

2. Identifying superior strains of nitrogen-fixing bacteria.

3. Studying the nature of genetic shifts in landraces and relating these findings to breeding strategies as well as to socio-cultural considerations.

The CRSP projects with a major commitment to addressing plant response limitations include:

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

   University of Wisconsin/Empresa Brasileira de Pesquisa Agropecuária [EMBRAPA](Brazil)

2. "Improving Resistance to Environmental Stress in Beans through Genetic Selection for Carbohydrate Partitioning, Water-Use Efficiency and Efficiency of Biological Nitrogen Fixation"

   Michigan State University/Instituto Nacional de Investigaciones Agrícolas [INIA](Mexico)

3. "Genetic, Agronomic and Socio-Cultural Analysis of Diversity among Bean Landraces in Malawi"

   Michigan State University/Bunda College of Agriculture (Malawi)

SELECTED ACHIEVEMENTS:

1. Improved strains of bean rhizobium have been identified that have increased bean yields from 500 kg/ha to 1,600 kg/ha following inoculation. The combination of superior cultivars with improved strains of rhizobium will enable low-resource farmers to maximize their nitrogen fertilization at very little expense.

2. Cultivars of black beans have been identified that fix up to 60 kilograms of nitrogen per hectare under field conditions. Results show that there are heritable differences in the ability to fix increased amounts of nitrogen among common bean genotypes.

3. Extensive germplasm of beans and cowpeas has been collected and evaluated for use in the breeding programs. Germplasm with disease and insect resistance, good cooking quality, high yield and various stress tolerances have been identified.

IV. LIMITATIONS OF THE PHYSICAL ENVIRONMENT

Many aspects of the physical environment influence the growth and development of beans and cowpeas. Four important aspects of the physical environment known to influence cowpea and bean productivity are: (1) environmental control of germination, flowering and maturity; (2) soil and water relations; (3) heat; and (4) solar radiation through its effects on yield potential. Critical tasks face CRSP scientists addressing these issues. The first task is to identify those aspects of the physical environment that most substantially influence small-scale cowpea and bean productivity in developing countries. A second task is to characterize the nature of the limitations imposed by the physical environment in different climatic zones so that solutions can be developed which are appropriate to the different production regions and farmer resources.

Environmental influences on germination, flowering and maturity are important factors in the productivity potential of beans and cowpeas. Their growth cycles are strongly influenced by the impact of photoperiod and temperature on date of flowering, two factors which contribute to zonal variations.

Drought is recognized as one of the major constraints limiting productivity of cowpeas in developing countries where they are mainly grown as a rainfed crop in semiarid zones and where limited rainfall results in substantial water deficits virtually every year. Common beans are extremely sensitive to drought. Developing cultivars with improved adaptation to drought is extremely

complex initially because it is essential to understand the characteristics of the environment (climatic cycles, soil profiles, etc.) that determine the timing and impact of droughts and their variability. Regional differences are important. For example, rainfall tends to be more variable in drier environments. Characterization of the target environment then permits the rational design of improved drought tolerant cultivars and management practices. Drought can also have major influences on cowpeas and beans through effects on the incidences of plant diseases.

Heat is another significant constraint. High temperatures accentuate drought because of higher evaporative demands, increased water use and more extreme plant-water deficits. It has also been proposed that heat is a factor in flower and pod abortions, thereby lowering plant yields.

While yields have increased significantly for many crops, the yields of beans and cowpeas have remained static. Bean and cowpea cultivars usually exhibit non-uniform light distribution in their canopies, which may detract from yield. In addition, for cowpeas, very few well-adapted, determinate cultivars have been developed. Research is needed to design ideotypes for beans and cowpeas for increased yield potential.

CRSP projects are addressing the following research areas:

1. Determining how climatic variables affect adaptation, growth and yield of beans and identifying the genes responsible.

2. Identifying the plant mechanisms and developing techniques of screening for characteristics that confer drought adaptation and heat resistance.

3. Identifying sources of drought tolerance and heat resistance.

4. Incorporating heat and drought tolerance into germplasm for breeding programs in the US, Africa and Latin America.

5. Designing bean and cowpea ideotypes to increase yields.

The CRSP projects with a major commitment to addressing physical environment constraints include:

1. "Developing Improved Cowpea Cultivars, Management Methods and Storage Practices for Semiarid Zones"

   University of California-Riverside/Institut Sénègalais de Recherches Agricoles [ISRA](Senegal)

2. "Agronomic, Sociological and Genetic Aspects of Bean Yield and Adaptation"

Cornell University/Instituto de Ciencias y Tecnología Agrícola [ICTA](Guatemala)

SELECTED ACHIEVEMENTS:

1. In spite of the drought in 1985, Senegal increased cowpea production fivefold by utilizing research findings of the CRSP. Seven hundred tons of California Blackeye No. 5 seed were shipped from California to Senegal in June 1985. With the introduction of this cultivar, cowpea production increased in Senegal from 16,000 tons in 1984 to 80,000 tons in 1985. During this serious food shortage period in Senegal, over one million people were fed with this cultivar. Early-maturing cowpea cultivars such as this one are important in the food balance equation for subsistence and low-input farmers in the Sahelian region.

2. International testing has proven effective in unraveling the photoperiod reactions in beans. Tropical locations in Guatemala have proven very useful in assaying the control over days to flower and maturity of beans by photoperiod and temperature.

3. Bean research has indicated that yield potential is positively correlated with the duration from germination to maturity, whereas for cowpeas, research indicates that yield potential is determined by the duration from first flowering to maturity.

4. Climbing bean ideotypes have been developed for use in corn intercropping systems.

5. Several short-cycle cowpea lines were developed which produce two to four times as much grain as local Sahelian cowpeas in extremely dry years.

6. Cowpea lines were identified which have substantial heat tolerance at flowering (Prima, TVU 4552 and PI 204647), extensive root systems (Grant and Bambey 21) and early flowering over a broad range of photoperiods and temperatures (UCD 7694, UCR 193, Rawal 4-1 and IT 82E-18).

V. PRODUCTION-CONSUMPTION ECONOMICS, FARMING SYSTEMS AND SOCIO-CULTURAL FACTORS

The major goal of the Bean/Cowpea CRSP is to contribute to the alleviation of hunger and malnutrition through research on the production and utilization of beans and cowpeas. To achieve this goal, both biological and socio-economic factors are considered in the generation of new agricultural technologies for small-scale farmers.

Several of the CRSP projects have an active interface between agricultural scientists and social scientists. Research agendas for these projects have been planned with the participation of the social scientists concerned with macro- and micro-level constraints of the farm family and production systems. Both baseline data and ongoing research (which monitors need, changes and the impact of policies) contribute to project success.

This constraint group is addressing the following issues:

1. Technology development and adoption.
2. Land tenure and land pressure.
3. Labor constraints.
4. Capital, pricing policies and foreign exchange.
5. Crop management practices.

The CRSP projects with a major commitment to production/consumption economics, farming systems and socio-cultural factors include:

1. "Agronomic and Sociological Aspects of Bean Yield"

   Cornell University/Instituto Nacional de Investigaciones Agropecuarias [INIAP](Ecuador)

2. "Development of Integrated Cowpea Production Systems in Semiarid Botswana"

   Colorado State University/Botswana Ministry of Agriculture (Botswana)

3. "Breeding Beans (Phaseolus vulgaris L.) for Disease, Insect and Stress Resistance and Determination of Socio-Economic Impact on Smallholder Farm Families"

   Washington State University/Sokoine University of Agriculture [SUA](Tanzania)

4. "Genetic, Agronomic and Socio-Cultural Analysis of Diversity among Bean Landraces in Malawi"

   Michigan State University/Bunda College of Agriculture (Malalwi)

SELECTED ACHIEVEMENTS:

1. Relevant information has been gathered on food preferences, legume cooking characteristics and nutrition-related factors in the areas where the projects are located. Farm labor utilization and allocation practices have also received study. This information permits improved varieties to be developed that are compatible with local resources.

2. Investigators in Cameroon and Malawi report the critical importance of yield stability. This criterion seemed to underlie the bean mixtures or cowpea mixtures traditionally planted in several of the countries studied. Individual landraces within the mixture performed differently in response to varying ecological conditions. In developing improved cultivars, the need for increased research on mixtures, including research on producer handling and on the maintenance of hybrid genetic structure, was emphasized because many farmers indicated they would continue to grow mixtures even if given improved new cultivars.

3. In Tanzania, it was documented that females provide 50 percent of the labor for major cash crops. They provide a much higher percentage of the labor for the considered minor, but critical, food crops where they are responsible for weeding, harvesting, threshing and processing. In this and other countries where CRSP projects are located, innovations in food production technology that conflict with women's roles as contributors to the major crop may produce serious production cycle/labor conflicts or may not be adopted at all.

   A case drawn from Malawi further illustrates this point. Here, when a new maize cultivar was developed and introduced, it has unforeseen consequences. The new maize was a longer season cultivar which conflicted with labor requirements during the major bean production season. Adoption of this new high-yielding maize resulted in a delayed harvest of beans, increased insect damage in the field and overall reduced bean yields.

4. The importance of dialogue with farmers was highlighted by findings from Ecuador. National program efforts to develop a pole bean that would grow well with an early-maturing maize cultivar were discontinued when it was learned through CRSP research that farmers in the region monocropped the new maize variety and followed it with a relay crop of beans or peas. The relative importance of other crop-use factors for the Ecuador breeding programs was also determined.

5. The study of farmers' practices led to changes in recommended plant-spacing patterns and other plant-management practices. For example, in Ecuador, farmers were using plant-spacing distances far greater than those recommended by scientists. Research, however, demonstrated that manual weed control as practiced by the farmers required the spacing distances actually being used by them, a finding which also had impact on other recommended plant-management practices. These findings reinforced that new crop varieties and agronomic practices compatible with existing farming systems and cropping calendars stand a better chance of acceptance and success than those that are alien.

6. Careful research into farming systems allows key production and utilization constraints to be identified and addressed. In Botswana, for example, collaborative research revealed that many farming households were headed by women who lacked access to adequate draft power to prepare their fields. This information was used to develop agricultural technology (i.e., minimum till ridger/planter) that relies for traction power on a smaller number of animals which are more easily handled by women (i.e., donkeys). Multiples of these implements are being provided to the extension service for evaluation in the field.

7. Solid collaborative relationships evolving among social and agricultural scientists at US and HC institutions are among the most important achievements of the CRSP. This is especially apparent from the benefits to research and training efforts derived from attention to the women-in-development (WID) perspective throughout the CRSP. Recognition of the complex interactions between biological and socio-economic factors in agricultural development is crucial if there is any hope that problems of hunger and malnutrition can ultimately be solved. The partnerships, established among the CRSP scientists from many disciplines, provide a strong foundation for the research efforts of the future.

VI. STORAGE, FOOD PREPARATION, NUTRITION AND HEALTH

Beans and cowpeas are important protein foods in many tropical and sub-tropical areas. The nutritional quality of these legumes can be improved through breeding, biotechnology and other methods. Both beans and cowpeas are susceptible to development of the "hard-to-cook" phenomenon which requires more time and fuel for preparation as well as reduces seed germination and viability. Large quantities of legumes are lost to insects through poor storage facilities/technologies.

Beans and cowpeas are considered "a poor man's food," an image which constrains consumption. There is indication that above a certain level, as personal incomes increase, consumption of beans and cowpeas may in fact decrease. Improvement of the image of beans and cowpeas, as primary contributors to good health and nutrition rather than an associate of poor income or intestinal distress, is necessary to enhance consumer acceptability.

The research objectives within this constraint area include:

1. Determining the process whereby cowpeas and beans develop the hard-to-cook phenomenon during storage.

2. Investigating the effects of natural anti-nutritional constituents of cowpeas and beans on nutritional quality.

3. Developing standard methods to assay cooking and nutritional quality, both for consumer acceptability and breeding programs.

4. Developing 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.

5. Designing a village-scale process to produce a convenient, stable, functional, nutritious cowpea product.

The CRSP projects with a major commitment to storage, food preparation, nutrition and health-related activities include:

1. "Improved Biological Utilization and Acceptability of Dry Beans"

   Washington State University/Instituto de Nutrición de Centroamerica y Panamá [INCAP](Guatemala)

2. "Appropriate Technology for Cowpea Preservation and Processing and a Study of Its Socio-Economic Impact on Rural Populations in Nigeria"

   University of Georgia/University of Nigeria-Nsukka (Nigeria)

3. "Medical Aspects of Feeding Cowpeas to Children"

   Michigan State University/Universities of Jos and Ibadan (Nigeria)

SELECTED ACHIEVEMENTS:

1. Surveys were conducted in several countries consuming large quantities of beans and cowpeas to establish patterns of consumption, methods of preparation, medical and health problems associated with their consumption.

2. A small village mill was constructed in Ogbodu-Aba, Nigeria, to process cowpea meal using technologies developed in the project. This mill is the property of the Village Development Union.

3. Studies indicate that the hard-to-cook phenomenon in beans is caused by the interactions of phytate, proteins and minerals. The quantitative relationship among phytate, calcium and magnesium is predictive of cooking time.

4. Two processing treatments have been developed that minimize bean hardening.

VII. EDUCATION, TRAINING AND RESEARCH CAPABILITY

Another major objective of the Bean/Cowpea CRSP is to develop a cadre of research personnel needed to promote bean and cowpea production and utilization throughout the world. Degree training was provided in various disciplines including breeding, food technology, entomology, plant pathology, agricultural economics, extension, horticulture, sociology, statistics and agronomy. There were 90 students (54 males and 36 females) who completed degree programs in the first 5.6 years. Of these, 56 were from Host Countries and other developing countries, while 34 were from the US. These "problem solvers" will provide leadership in bean and cowpea research programs for the next decades.

The CRSP also provided significant non-degree training opportunities for 758 researchers (543 males and 215 females). Of these, 684 were from Host Countries and other developing countries. Examples of these training courses include biological nitrogen fixation, food technology, computers, farming systems, remote sensing, bean quality, nematology, data analysis, bean rust, plant resistance to insects, and nutrition. The training varied from several days to several months. Each course fulfilled a specific training need which was identified to help support a research effort. Training was provided at US universities, International Agricultural Research Centers and Host Country research institutions.

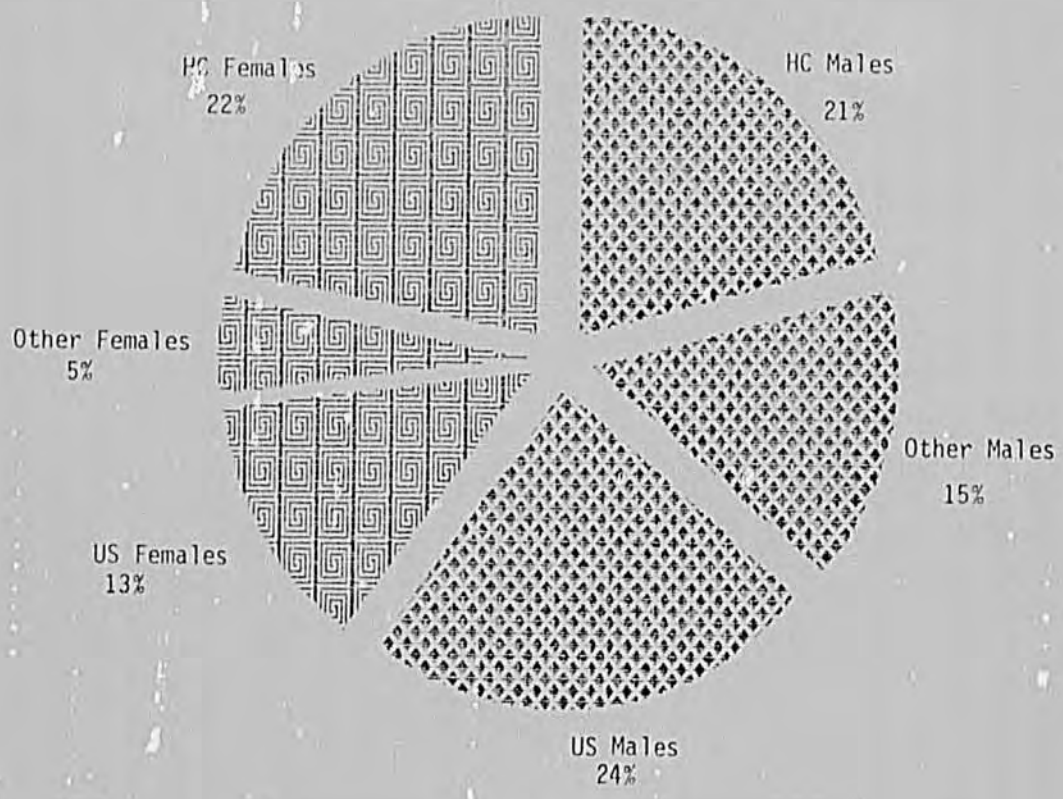
These training activities have had a dramatic impact upon the bean and cowpea research programs throughout the world. They have strengthened the institutions in thirty-one countries, including the US.

Workshops were conducted by the CRSP to strengthen the research capabilities of the participants. The Biological Nitrogen Fixation Workshop in Madison, Wisconsin reviewed the latest developments in this fast-moving research area. The MSTAT Workshop at Michigan State University showed how microcomputers could be used to design, manage and analyze agricultural research. The Dry Bean Quality and Women and Food Concerns Workshop at Washington State University reviewed the importance of bean quality and highlighted current methodologies in food technology. The Socio-Agronomic Workshop at Michigan State University highlighted the importance of the integration of social concerns with agronomic technologies. The Tepary Bean Workshop in Mexicali, Mexico helped to focus the potential of the tepary bean as a source of genetic material for bean improvement programs.

The Workshop on Drought and Temperature Tolerance in Beans and Cowpeas in Durango, Mexico provided a forum for researchers concerned with drought to clarify drought issues and progress and to discuss future research needs in this area. Finally, the World Cowpea Research Conference, co-sponsored by the CRSP and IITA, brought cowpea researchers from all over the world to discuss research programs and devise strategies for solving problems.

BEAN/COWPEA CRSP

M.S. AND PH.D. DEGREES COMPLETED, MAY 6, 1986
Gender Distribution



SIGNIFICANT ACCOMPLISHMENTS

VIRTUALLY EVERY US BEAN PROGRAM, WHETHER PUBLIC OR PRIVATE, IS BEING HELPED DIRECTLY OR INDIRECTLY THROUGH RESEARCH EFFORTS OF ONE OR MORE OF THE CRSP-RELATED PROJECTS. These benefits are in the form of basic and applied information and new germplasm resources from around the world which will lead to improved US cultivars, better production practices and nutritional quality. Basic research in bean plant physiology and genetics is unlocking important doors leading to increased yield potential. CRSP activities have made available to researchers new sources of disease and insect resistance which have been incorporated into their breeding programs. Extensive efforts in germplasm collection and preservation have contributed valuable germplasm to the world collection. These efforts will help buffer the serious consequences of past genetic erosion of bean and cowpea germplasm. The Bean/Cowpea CRSP has had significant impact on the domestic bean/cowpea research programs as well as helping many developing country programs.

IN SPITE OF THE DROUGHT IN 1985, SENEGAL INCREASED COWPEA PRODUCTION FIVEFOLD BY UTILIZING RESEARCH FINDINGS OF THE BEAN/COWPEA CRSP. Researchers at the University of California-Riverside have been working with the national cowpea researchers in Senegal developing strategies and technologies to deal with the serious drought prevalent throughout the Sahel region. In early 1985 the CRSP project worked with the USAID Mission and European Economic Community delegation to solve a serious shortage of peanut and cowpea seed in Senegal. CRSP research had identified a cultivar which performed well in Senegal. Seven hundred tons of California Blackeye No. 5 seed were shipped from California to Senegal, arriving in June 1985. This seed provided approximately 100,000 farmers with seed to plant. With the introduction of this cultivar, cowpea production increased in Senegal from 16,000 tons in 1984 to 80,000 tons in 1985. During this serious food shortage period in Senegal, over one million people were fed with this new cultivar. Early-maturing cowpea cultivars such as this one are important in the food balance equation for subsistence and low-input farmers in the Sahelian region.

SEVERAL CRSP PROJECTS HAVE MADE SCIENTIFIC DISCOVERIES WHICH HAVE GLOBAL SIGNIFICANCE. THE BEAN COMMON MOSAIC VIRUS ANTISERA AND SERODETECTION PROTOCOLS DEVELOPED BY RESEARCHERS AT WASHINGTON STATE UNIVERSITY ARE BEING USED TO

INSURE FARMERS OF DISEASE-FREE SEED AS WELL AS PREVENT THE SPREAD OF BEAN COMMON MOSAIC VIRUS TO NEW REGIONS. This methodology is rapid, inexpensive and does not require sophisticated training equipment or facilities. This knowledge will greatly facilitate the correct choice of parents for breeding programs and will improve the efficiency of screening segregating populations while developing new cultivars with virus resistance. This procedure is being used by USDA and International Agricultural Research Center personnel.

The CRSP workers at the University of Wisconsin and Michigan State University have been collaborating with the national program in Brazil to improve the nitrogen-fixation capability of beans. It was found that there are heritable differences in ability to fix increased amounts of nitrogen between common bean genotypes. CULTIVARS OF BLACK BEANS HAVE BEEN IDENTIFIED THAT FIX UP TO 60 KILOGRAMS OF NITROGEN PER HECTARE UNDER FIELD CONDITIONS. In addition to selecting superior bean cultivars, this project has also identified improved strains of the nitrogen-fixing bacteria, rhizobium. In a trial in Cerrado using selected strains of rhizobium, yields were increased from 500 kg/ha to 1600 kg/ha following inoculation. The combination of superior cultivars with improved strains of rhizobium will enable low-resource and subsistence farmers to maximize their nitrogen fertilization at very little expense. Methodologies developed in this project can also be used in other legume systems, both in the US and developing countries.

RESEARCH AT THE INSTITUTO DE NUTRICIÓN DE CENTROAMERICA y PANAMÁ (INCAP) AND WASHINGTON STATE UNIVERSITY LINKS BEAN PRODUCTION-ORIENTED RESEARCH WITH SCIENTIFIC IMPROVEMENTS IN CONSERVATION, ACCEPTABILITY, COOKING QUALITY AND NUTRITION. The research programs address factors responsible for bean quality, nutritional quality, processing and food product development. Considerable effort has been focused on the hard-to-cook phenomenon which renders beans unduly firm after cooking, lowers the nutritive value and requires more fuel for cooking. INCAP research shows that two processing treatments can minimize or control bean hardening. Genetic and environmental factors have been identified which cause the hard-to-cook problem. By incorporating germplasm into cultivars which require less cooking time, firewood/fuel requirements in many areas can be greatly reduced. This factor alone will have significant impact on subsistence economies as well as reduce environmental degradation due to firewood collection.

WORK AT KANSAS STATE UNIVERSITY INDICATES THAT HARD-TO-COOK BEANS ARE PROBABLY NOT DUE TO

UNGELATINIZED STARCH OR FAILURE OF THE RAW BEAN PROTEIN TO DENATURE. Water migration does not limit cooking time of beans. Studies at Washington State University showed that the interactions of phytate, proteins and minerals relate to the hard-to-cook phenomenon. Quantitative relationships among phytate, calcium and magnesium are predictive of cooking time.

WOMEN IN DEVELOPMENT (WID) HAS PLAYED AN IMPORTANT ROLE IN THE PROGRAM ACHIEVEMENTS OF THE CRSP. Principal investigators in the agricultural sciences have been provided with ready access to information on the social and economic parameters of agricultural production and utilization in the Host Countries through the publication of a series of Women in Agriculture Resource Guides. This information has assisted in the development of research agendas that are socially as well as agronomically sound. For example, recognizing that lack of access to draft power represents an important constraint to timely planting for many of the one-third of rural households headed by women in Botswana, CRSP researchers are designing implements that reduce draft power requirements. In Cameroon, new and improved cowpea cultivars are being developed that take into account the multiplicity of uses of cowpea plants (for human consumption in the form of leaves, pods and dried cowpeas and for animal fodder) in the farming systems. In addition to its contributions in the area of research, WID has achieved significant results in the area of training, actively recruiting qualified women to participate in the CRSP's degree training program. Over one-third of those who received degrees under CRSP auspices during the first five years of the grant and almost half of those currently enrolled in degree programs are women.

A major objective of the CRSP is to insure sufficient human resources to promote bean and cowpea production and utilization throughout the world. The Bean/Cowpea CRSP has a very impressive training record. THERE ARE 90 RESEARCHERS WHO HAVE COMPLETED DEGREE TRAINING (54 MALES AND 36 FEMALES) WHILE 758 HAVE COMPLETED NON-DEGREE TRAINING PROGRAMS (543 MALES AND 215 FEMALES). These "problem solvers" will be able to provide the dynamic and innovative leadership necessary to identify and solve the problems which are before us.

THIS CRSP HAS BEEN ABLE TO ESTABLISH A NETWORK OF BEAN AND COWPEA RESEARCHERS THROUGH CONFERENCES, SUMMER WORKSHOPS AND RESEARCH PROGRAMS. This network has provided the linkages necessary to address the important issues and to develop strategies pertaining to bean and cowpea production and utilization. This network has also accessed other agricultural programs in the pursuit of scientific understand-

ing as well as applied agriculture. It has also given many scientists in developing countries the opportunity to work collaboratively with scientists in the United States, gain exposure to current techniques and research methodologies and have access to sophisticated equipment and supplies which would otherwise be unavailable to them. The CRSP has been very effective in getting the involvement of basic scientists in international development activities.

THE DEPLOYMENT OF NEW TECHNOLOGIES AND METHODOLOGIES BY THIS NETWORK OF RESEARCHERS IS VERY IMPORTANT. Twenty-three students and researchers completed an intensive microcomputer workshop which showed how the researchers could utilize microcomputer technology in their research programs. The CRSP has provided microcomputers to many programs which will maximize the efficiency of trained personnel. Other workshops included (1) Biological Nitrogen Fixation, (2) Dry Bean Quality and Women and Food Concerns, (3) Socio-Agronomic, (4) Tepary Bean, (5) Drought and Temperature Tolerance and (6) Utilization of Grain Legumes and Grain.

THE CRSP HAS MADE SEVERAL CONTRIBUTIONS TO THE COWPEA BREEDING PROGRAM IN CALIFORNIA WHICH DEPENDS MAINLY ON A CULTIVAR DEVELOPED MORE THAN 40 YEARS AGO. New cultivars are needed because the present cultivar is sensitive to heat and to a major disease--fusarium wilt. The CRSP made possible the discovery of heat-tolerant germplasm which is now being used to develop improved cultivars for California. Heat-tolerant genes identified by this CRSP research are just one of the new sources of important germplasm needed for the development of improved new cultivars.

FROM 1500 BEAN LINES SCREENED ANNUALLY IN MEXICO, A NUMBER HAVE BEEN IDENTIFIED WITH DROUGHT TOLERANCE. Pinto Nacional I was identified to have drought resistance and was recommended to farmers. Several drought tolerant lines were identified which were included as germplasm in crossing programs; these included N81017, Ags77, Ags41, Zacatecas 89-79 and Durango 5.

THE CRSP HAS FACILITATED MULTIDISCIPLINARY RESEARCH BY FOCUSING ATTENTION ON THE NEEDS OF SMALL-SCALE PRODUCERS OF BEANS AND COWPEAS. The CRSP has stimulated many bean and cowpea research programs throughout the world. "Practical lessons" and "scientific principles" learned from these expanded programs have been utilized in the United States as well as developing countries.

IN CAMEROON THE CRSP HELPED TO IDENTIFY A HIGH YIELDING CULTIVAR, TVX 3236, FOR WHICH SEED DEMAND HAS GONE FROM FIVE TONS IN 1984 TO FORTY-SEVEN TONS IN 1986. With improved cultivars and pest management introduced by the CRSP project, farmers can expect average yields of 600-1200 kilograms per hectare compared to 300 kilograms before the CRSP project.

APPROXIMATELY 200 STRAINS OF INSECT PATHOGENIC FUNGI ARE NOW AVAILABLE TO THE SCIENTIFIC COMMUNITY FOR BIOLOGICAL INSECT CONTROL RESEARCH. Boyce Thompson Institute has conducted research on the biological control of cowpea and bean pests with insect pathogens. Since there was virtually no information on the diseases of insect pests of these crops before the CRSP, an initial objective was to survey fields for diseased pests. Cultures of disease agents were obtained, identified, and placed in liquid nitrogen storage. These pathogenic fungi are being tested for the control of several major cowpea pests.

AT BOYCE THOMPSON INSTITUTE FOUR OUT OF TWO HUNDRED COWPEA LINES FROM GEORGIA SHOWED AN ANTIBIOSIS RESISTANCE TO THE COWPEA APHID. It was also shown that aphid-resistant lines from IITA were not resistant to the Georgia population of the cowpea aphid. These findings show that breeding strategies need to consider biotype differences in their programs.

THE COLLABORATION OF CORNELL UNIVERSITY CRSP WORKERS WITH CIAT, ECUADOR AND GUATEMALA HAS IDENTIFIED VALUABLE GERMPLASM FOR THE NEW YORK BREEDING PROGRAM. Crosses are being made between New York bean cultivars and those identified as being later to flower with a mechanism other than sensitivity to long daylength and high temperature. This later maturity caused by non-photoperiod sensitivity should facilitate higher yields of beans in the long summer days of New York.

THE CORNELL CRSP PROJECT INVOLVEMENT IN INTERNATIONAL TESTING HAS PROVEN VERY EFFECTIVE IN UNRAVELING THE PHOTOPERIOD REACTIONS IN BEANS. Tropical locations in Guatemala have proven more effective in assaying the control over days to flower and maturity of beans by daylength and for high temperature than is the climate of New York State. This enhanced our ability to select for different maturities that are needed to maximize cultivar adaptation and bean yields for many different locations, including the temperate climate of New York State, the lowland tropics, moderate elevation tropics and the highland tropics.

CORNELL'S CRSP RESEARCH IN GUATEMALA HAS FOUND THAT ABILITY OF CLIMBING BEAN CULTIVARS TO COMPETE WITH THE ASSOCIATED CORN CROP IS CONDITIONED PRIMARILY BY THE CULTIVAR'S MATURITY AND THE POSITION ON THE STEM OF FLOWERS AND PODS. That is, early vs. late maturity plus vertical distribution of the pods along the stem constitute the primary genetic variability needed by plant breeders in climbing beans. This information is being utilized by Guatemala's Institute of Science and Technology of Agriculture in their program to breed climbing bean cultivars for the native Indian farmers of the highlands.

PRELIMINARY CRSP RESEARCH IN GUATEMALA HAS SHOWN THAT CHILDREN EATING SIGNIFICANT QUANTITIES OF BEAN BROTH REPORTED FEWER INCIDENCES OF DIARRHEA AND WERE TALLER AND HEAVIER THAN CHILDREN EATING LITTLE BEAN BROTH. The diets of children not fed bean foods contained significantly less protein and energy than diets containing bean foods. Research on digestibility of protein, water uptake, protein quality and quantity and antinutritional factors in beans will lead to the development of improved cultivars which can improve the diets of urban and rural populations.

THREE BEAN CULTIVARS WERE IDENTIFIED WITH RESISTANCE TO THE BEAN FLY, *OPHIOMYIA PHASEOLI*. These lines are being incorporated into the crossing programs in Tanzania and CIAT.

STUDIES AT BOYCE THOMPSON INSTITUTE INDICATED A WIDE RANGE OF VEGETABLE AND MINERAL OILS PROVIDED SHORT-TERM PROTECTION OF THE SEED. The bruchid storage beetle causes serious post-harvest losses. Efficacy of oils was greatly improved when containers were closed, indicating the potential for the use of sealed containers as a control strategy, replacing the costly and dangerous insecticides.

THE COLORADO STATE UNIVERSITY/BOTSWANA PROJECT HELPED TO DEVELOP AND TEST TWO NEW FIELD CULTIVATION IMPLEMENTS. The ridgeshaper/planter is suitable for soils with eight or more centimeters of friable surface soil and no compaction. It can be pulled by two donkeys in coarse-textured soils. It can be fabricated locally at very low cost. The cultivator/planter is capable of preparing a seedbed on plowed or unplowed land and planting at the same time. It is readily adaptable to strip tillage if desired. Draft requirements are two oxen or four donkeys.

RESULTS FROM EXPERIMENTS CONDUCTED AT THE UNIVERSITY OF GEORGIA DESIGNED TO ENUMERATE *ASPERGILLUS FLAVUS* IN COWPEAS AND IN COWPEA FLOUR REVEAL THAT *A. FLAVUS* AND *A. 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.

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.

IN GENETIC STUDIES AT MICHIGAN STATE UNIVERSITY IT WAS SHOWN THAT DOMINANCE IS GREATER THAN ADDITIVE VARIANCE FOR IMPORTANT CULINARY AND NUTRITIONAL TRAITS OF DRY EDIBLE BEANS. Studies have also shown that selection in early generations is possible for trait improvement. Protein and procyanidin were shown to be inherited quantitatively.

THE UNIVERSITY OF NEBRASKA/DOMINICAN REPUBLIC PROJECT OBTAINED INFORMATION ON THE INHERITANCE OF RESISTANCE TO COMMON BLIGHT AND RUST. They found that the reaction of leaves and pods to common blight were inherited quantitatively and that different genes controlled resistance reaction in different plant parts. A simply inherited hypersensitive reaction was detected in some sources of common blight resistance. Bacteriophage typing studies substantiated the wide variation among strains of common blight in the Dominican Republic and the distribution of strains was random.

POMPADOUR CHECA, A RED MOTTLED DRY BEAN, WAS IDENTIFIED AS RESISTANT TO ALL KNOWN STRAINS OF RUST IN THE DOMINICAN REPUBLIC AND NEBRASKA. The rust reaction was determined by two major genes with resistance being expressed in the presence of a major gene exhibiting epistasis.

THE UNIVERSITY OF WISCONSIN, WORKING WITH EMBRAPA IN BRAZIL, HAS DEVELOPED INOCULATION TECHNIQUES FOR THE SEQUENTIAL INOCULATION OF FOUR MAJOR BEAN DISEASES (RUST, COMMON BLIGHT, ANGULAR LEAF SPOT AND ANTHRACNOSE). This will expedite the development of multiple disease resistant bean cultivars which will help stabilize bean yields.

THE UNIVERSITY OF PUERTO RICO, IN COOPERATION WITH RESEARCHERS IN THE DOMINICAN REPUBLIC AND

HONDURAS, HAVE DEVELOPED BEAN CULTIVARS WITH MULTIPLE DISEASE RESISTANCE. Several cultivars have been released by this program and are providing farmers with stable yields. The white-seeded cultivar, Arroyo Loro, has done well in both the Dominican Republic and Puerto Rico. Germplasm with disease resistance has also been identified and released for plant breeders to use in their breeding programs. These lines are important sources of resistance to rust, bean common mosaic virus, angular leaf spot, common blight and web blight.

THE UNIVERSITY OF CALIFORNIA-RIVERSIDE PRODUCED SEVERAL POPULATIONS OF INTERSPECIFIC HYBRIDS BETWEEN THE COMMON BEAN AND THE TEPARY BEAN. These progeny were evaluated for drought tolerance in Kenya.

RESEARCHERS AT MICHIGAN STATE UNIVERSITY ARE STUDYING THE ORIGIN AND MAINTENANCE OF GENETIC DIVERSITY IN MALAWI BEAN LANDRACES. They are looking at farmer practices as well as natural events which contribute to diversity. Farmer surveys, electrophoresis and other techniques are being utilized to understand diversity.

A SMALL VILLAGE MILL WAS CONSTRUCTED IN OGBODU-ABA, NIGERIA, TO PROCESS COWPEA MEAL USING SMALL-SCALE TECHNOLOGIES DEVELOPED IN THE PROJECT. The mill will be run by the Village Development Union, under the guidance of its Board of Directors. The management of the mill is organized to work effectively within the social structure of this traditional African village.

Summary and Financial Report

SUMMARY

Over the first five-plus years of its existence, the Bean/Cowpea CRSP has been able to establish collaborative research projects with leading US and HC researchers in Africa and Latin America. The achievements of this teamwork have been most impressive.

The CRSP has had significant impact on bean and cowpea availability in many countries. New varieties and production practices, new food preparation techniques, improved food quality, new pest control potential and increased nitrogen fixation are some of the areas where the CRSP has made important contributions.

Virtually every US bean and cowpea program, whether public or private, is being helped through the many research activities of this CRSP. A major example is the extensive efforts in germplasm collection and preservation which have contributed important germplasm to the world collection available for variety development programs.

In addition to the research activities, the CRSP has provided training opportunities for US and HC researchers. These scientists will provide important leadership in identifying and solving troublesome agricultural problems in the years ahead.

Thus, the CRSP has concentrated on maintaining a well-integrated research and training program. It has attempted to strike a balance between the research needs of legume science for the common good and the more narrow special needs of participating US and HC research programs. A high level of communication among the participants and especially across the disciplines supports this balance. Project leaders are now turning to one another for assistance in specified areas.

Slowly the real value of the resources represented by an organization of this size and complexity is making itself understood. The constraints identified are complex and stubborn, and long-term research is expected to be required if they are to be adequately addressed. If there is any hope that this process can be accelerated, it will be through assembling competent, dedicated persons who are heterogeneous in their professional and cultural backgrounds. Unencumbered by gender discrimination and national neglect, this resource is best described as intellectual germplasm. And indeed, it is the true promise of the Bean/Cowpea CRSP.

BEAN/COWPEA COLLABORATIVE RESEARCH SUPPORT PROGRAM

September 1980

Country	US Direct Costs (A)	US Indirect Costs (B)	HC Direct Costs (C)	HC Indirect Costs (D)	Total US Costs (E)	Total HC Costs (F)
Botswana/CSU	178,838 (83%)	35,526 (17%)	468,120 (83%)	97,188 (17%)	214,364 (27%)	565,308 (73%)
Brazil/BTI	419,037 (79%)	114,316 (21%)	331,956 (100%)	-0- (0%)	533,353 (62%)	331,956 (38%)
Brazil/UWI/Bliss	234,778 (77%)	69,400 (23%)	96,955 (100%)	-0- (0%)	304,178 (76%)	96,955 (24%)
Brazil/UWI/Maxwell	247,699 (78%)	69,365 (22%)	75,580 (100%)	-0- (0%)	317,064 (81%)	75,580 (19%)
Cameroon/UGA	201,907 (89%)	24,888 (11%)	536,664 (78%)	151,132 22%)	226,795 (25%)	687,796 (75%)
Dom. Rep./UNL	334,700 (74%)	115,501 (26%)	494,907 (98%)	9,050 (2%)	450,201 (47%)	503,957 (53%)
Dom. Rep./UPR	401,640 (93%)	30,892 (7%)	404,259 (99%)	5,801 (1%)	432,532 (51%)	410,060 (49%)
Ecuador/COR	360,345 (73%)	134,515 (27%)	179,719 (95%)	9,829 (5%)	494,860 (72%)	189,548 (28%)
Guatemala/COR	260,490 (65%)	139,922 (35%)	283,505 (96%)	12,505 (4%)	400,412 (58%)	296,010 (42%)
Honduras/UPR	275,276 (92%)	25,734 (8%)	363,347 (98%)	7,319 (2%)	301,010 (45%)	370,66[illegible] (55%)
INCAP/WSU	435,501 (77%)	129,740 (23%)	381,019 (84%)	73,136 (16%)	565,241 (55%)	454,155 (45%)
Kenya/UCD	463,174 (77%)	136,759 (23%)	282,351 (98%)	4,925 (2%)	599,933 (68%)	287,276 (32%)
Kenya/UCR	31,485 (58%)	22,876 (42%)	28,685 (100%)	-0- (0%)	54,361 (65%)	28,685 (35%)
Malawi/MSU	267,722 (74%)	94,209 (26%)	347,779 (100%)	-0- (0%)	361,931 (51%)	347,779 (49%)
Mexico/MSU	131,274 (74%)	47,045 (26%)	163,646 (99%)	244 (1%)	178,319 (52%)	163,890 (48%)
Nigeria/UGA	348,742 (84%)	68,303 (16%)	234,082 (100%)	-0- (0%)	417,045 (64%)	234,082 (36%)
Nigeria/MSU	52,340 (65%)	27,959 (35%)	162,523 (93%)	11,850 (7%)	80,299 (32%)	174,373 (68%)
Senegal/UCR	450,352 (75%)	147,343 (25%)	385,026 (86%)	60,880 (14%)	597,695 (57%)	445,906 (43%)
Tanzania/WSU	521,050 (69%)	232,230 (31%)	683,142 (99%)	6,626 (1%)	753,280 (52%)	689,768 (48%)
Uganda	53,641 (75%)	17,842 (25%)	29,241 (100%)	-0- (0%)	71,483 (71%)	29,241 (29%)
Total Country Research Projects	5,669,991 (77%)	1,684,365 (23%)	5,932,506 (93%)	450,485 (7%)	7,354,356 (54%)	6,382,991 (46%)
Distribution of Project Costs						
Cost Sharing AID/US					69%	
Management Office						
Total Grant Distribution						
Distribution of AID/US Contribution/HC Contribution						
Other:MSU Overhead, Balance Remaining, Audit						
TOTAL GRANT AID FUNDS						
Distribution of AID Indirect/Direct Cost						

FINAL FINANCIAL REPORT OF GRANT AID/DSAN-XII-G-0261

through May 6, 1986

Total US & HC indirect Costs (G)	US Direct Costs (H)	HC Direct Costs (I)	US Contrib. (M)	HC Contrib. (N)	Total Contrib. (O)	Total Cost
132,714 (17%)	178,838 (23%)	468,120 (60%)	116,350	119,340	235,690	1,015,362
114,316 (13%)	419,037 (49%)	331,956 (38%)	282,245	232,618	514,863	1,380,172
69,400 (17%)	234,778 (67%)	96,955 (16%)	45,091	16,174	61,265	462,398
69,365 (18%)	247,699 (63%)	75,580 (19%)	121,835	20,605	142,440	535,084
176,020 (19%)	201,907 (22%)	536,664 (59%)	439,148	215,475	654,623	1,569,214
124,551 (13%)	334,700 (35%)	494,907 (52%)	218,995	69,674	288,669	1,242,827
36,693 (4%)	401,640 (48%)	404,259 (48%)	185,581	100,254	285,835	1,128,427
144,344 (21%)	360,345 (53%)	179,719 (26%)	173,640	48,016	221,656	906,054
152,427 (22%)	260,490 (37%)	283,505 (41%)	195,893	120,244	316,137	1,012,559
33,053 (5%)	275,276 (41%)	363,347 (54%)	123,717	122,661	246,378	918,054
202,876 (20%)	435,501 (43%)	381,019 (37%)	271,553	138,674	410,227	1,429,623
141,684 (16%)	463,174 (52%)	282,351 (32%)	169,828	281,887	451,715	1,338,924
22,876 (28%)	31,485 (38%)	28,685 (34%)	24,936	-0-	24,936	107,982
94,209 (13%)	267,722 (38%)	347,779 (49%)	52,880	93,807	146,687	856,397
47,289 (14%)	131,274 (38%)	163,646 (48%)	70,571	85,152	155,723	497,932
68,303 (10%)	348,742 (54%)	234,082 (36%)	228,991	316,031	545,022	1,196,149
39,809 (16%)	52,340 (21%)	162,523 (63%)	69,968	127,150	197,118	451,790
208,223 (20%)	450,352 (43%)	385,026 (37%)	375,993	193,802	569,795	1,613,396
238,856 (17%)	521,050 (36%)	683,142 (47%)	210,473	161,667	372,140	1,815,188
17,842 (18%)	53,641 (53%)	29,241 (29%)	21,971	-0-	21,971	122,695
2,134,850 (16%)	5,669,991 (42%)	5,932,506 (43%)	3,399,659	2,463,231	5,862,890	19,600,237
	49%	51%				
			31%			
753,656 (28%)	1,957,612 (72%)					2,711,268
2,888,506 (13%)	7,627,603 (35%)	5,932,506 (26%)			5,862,890 (26%)	22,311,505
	16,448,615/74%		3,399,659/15%	2,463,231/11%		
	251,385					
	16,700,000					
17.5%	82.5%					