Improvement of Tropical Production of Beans and Cowpeas Through Disease and Insect Control (Extension) - University of Puerto Rico

Subcommittee: Dr. Maurice Peterson, Chairman, Drs. Max Milner, B. S. Schweigert and Robert Whitney.

This proposal is for an extension of present research to October 1978 with estimated funding level of $1,157,000 for the 31 month period.

Dr. Peterson appraised the current project and proposed extension indicating the subcommittee generally agreed continuation is justified. He noted that RAC approved this project January 8-9, 1973 with provisions that screening of breeding material for selected nutritive components be incorporated in the project activity. Specific concerns expressed then include (1) methionine content of beans and cowpeas, (2) toxicants in these species, and (3) socio-economic issues associated with protein strategy and changes in consumption patterns. He expressed the subcommittee's serious concern that these recommendations, and particularly those relating to nutritional factors, are not recognized in either the progress report or future work plan.

Dr. Peterson suggested greater progress could be expected by narrowing the objectives rather than broadening the scope of work to include other grain legume species as recommended in the "general appraisal." In support, he pointed out that area yields of grain legumes have been

essentially static (440 to 480 kg/ha) while cereal yields have increased 50% during the 1950-70 decades. Several basic problems impeding improvement have been identified, such as high flower abortion and lack of fertilizer response. Also, grain legumes include many distinct crop species which require separate breeding programs in contrast to rice or wheat. The project attempts to address all these problems but he suggested it is unrealistic to expect much progress from such a broad effort.

Dr. Peterson indicated it would be presumptious and not possible to suggest priorities on the basis of information in the reports, but he did offer some general comments. Specifically, he noted the virology work appears almost independent and asked, if it is intended to identify which diseases are most important, then what is to be done with the results? Similarly, he asked what the nematode work is intended to accomplish. He noted breeding for resistance is not planned even when chemical control seems impractical. Because each crop species becomes dissected into several programs for developing resistance to the complex of virus, fungus and bacterial diseases, insects, and nematodes, and is further complicated by classes of varieties, he suggested the project be strengthened with more promise for progress by including only the two crops, dry beans and cowpeas, with emphasis only on the major diseases and insects. Arrangements to share some of the specific objectives which may be difficult to attain in Puerto Rico, with U.S. institutions having appropriate facilities were suggested. These would include nutritional qualities as well as environmental limitations encountered in maintaining pure breeding lines. .

Dr. Schweigert expressed agreement with the report and complimented Dr. Peterson on the analysis. He further emphasized developing or limiting priorities for emphasis. He reported the project manager has been responsive to the nutrition and toxicant questions and is including these considerations in proper perspective.

Dr. Whitney noted that some germ plasm having disease and insect resistance has been released and distributed and suggested that some emphasis be shifted to genetics and breeding to further pursue this objective with these improved materials. He emphasized that close cooperation among scientists in the various disciplines would be necessary to achieve the objectives and release improved varieties.

Dr. Milner indicated trypsin determinations may be more difficult, but methionine could be easily evaluated by anyone having a basic bio-chemical facility. Dr. Schweigert indicated he did not believe all toxicants could be handled as easily as antitrypsin, which is one type, but that through breeding one could increase or decrease negative nutrition factors as well.

Mr. Keith Byergo, TA/AGR, reported that work on the nutrition aspects and specifically methionine is being done at the University of Wisconsin in close coordination with this project. He agreed with suggestions that limiting the work to a few varieties would be beneficial, and explained that the breeding efforts with a wide range of other varieties are only

to locate resistance genes which can be transferred into the common bean. Results of viral resistance studies are being fed into the breeding programs as quickly as possible for developing resistance. Close coordination has also developed among the breeders and pathologists working on fungus and bacterial diseases. He noted that at the recent beans and cowpeas workshop in Columbia it was suggested consideration be given to developing genetic resistance to the white fly vector. Close coordination of related work at CIAT, in Honduras, and other areas is in progress.

Dr. Peterson asked if it would be desirable to AID to convene a workshop of U.S. breeders in Puerto Rico to determine if parts of this total problem should be portioned out to address them with more talent than is available at the present. Mr. Byergo indicated there would be some merit in this, but since the emphasis is on tropical aspects of the problem the potential of this procedure would be limited even though there are techniques and expertise available in the U.S.

Dr. Baird indicated that CIAT has responsibility among the International Centers network for dry beans. Michigan State University has close coordination in their work with CIAT. He also reported a consortium of U.S. universities is being considered in this area and should include the University of Puerto Rico for disease and insect problems particularly in view of their location and developing expertise.

Motion: That the project be approved with the understanding that:

(a) The contractor sharpen the focus of the project on fewer and higher priority objectives, and

(b) AID take appropriate steps to coordinate the project activities at Puerco Rico with research on grain legumes at various U.S. universities and CIAT.

Moved by Dr. M. Peterson; seconded

Vote: Unanimous approval.

KPA 2-562
KAC Meeting
Jan. 8-9, 1973
9310562
PD-AAL-695

SUPPLEMENT TO PROJECT STATEMENT

November 6, 1972 17p

Improvement of Tropical Production of Beans and Cowpeas Through Disease and Insect Control

This project was submitted for review but withheld from discussion at the RIGC meeting on October 26, 1972 because of new developments which suggested the advisability of restructuring the proposal. As originally conceived, it was to be a cooperative project between the University of Puerto Rico and the USDA, with each assigned administrative responsibility within their respective areas of expertise as outlined in the original submission (dated September 28). As now proposed, the administrative responsibility for the project would be given to the University of Puerto Rico with key USDA personnel participating as members of the UPR research team. This would be much like the existing arrangement with the University of Nebraska in the highly successful winter wheat improvement project. In that case, the administrative responsibility for the project rests with the University, although one of the principal scientists is employed by the USDA.

Since its inception nearly ten years ago, the regional grain legume (pulse) improvement project, conducted under a PASA with the USDA in India and Iran and later in Puerto Rico, has made significant progress. It enabled India to develop a scientific base for an all-India pulse research program and at the same time provided technical assistance to the country's operational activities. It provided Iran with essentially the same kind of support in sufficient depth that the FAO has decided to use Iran, beginning in 1973, as a training base for pulse research workers in that part of the world. It has likewise been helpful to the University of Puerto Rico in the more than two years that the UPR has been actively engaged in this activity.

In addition to the above, increased research and training support to the major food legumes on an international basis is gradually being realized. To date, responsibility for developing international networks on major legumes has been assumed by the institutions listed below:

Crop	Responsible Institution	Authorizing Agent
Pigeon peas	ICRISAT - India	CG*
Chickpeas	ICRISAT - India	CG
Dry beans	CIAT - Colombia	Governing Board
Cowpeas	IITA - Nigeria	Governing Board
Mungbeans	AVRDC** - Taiwan	Governing Board
Soybeans	USA - University of Illinois	Under consideration by A.I.D., CG and Private Foundations

Further assignments for cooperative international food legume improvement are expected to follow. Those initially needing attention are groundnuts, peas, broadbeans and lentils in that order of priority. It is expected that the CG will be providing a rationale for a coordinated effort on these crops within the next year. Thus, the components are being established for international systems or networks for needed research and training for the major food legumes, as was done for wheat, corn, rice and more recently for sorghum, millet and barley.

These new activities in the international field relating to food legume improvement, and related developments which are likely to take place, have caused TA/AGR over the last 12 to 15 months to take a new look at the role of A.I.D. in supporting international research in the food legume field. It is precisely because of these developments that TA/AGR has narrowed its focus to a specific area of activity which is of high priority, holds promise of a breakthrough, and for which the Puerto Rico research team has a current advantage in experience and capability. The selected area of activity is confined to diseases and insects of beans, cowpeas and related wild legumes. Both beans and cowpeas have high consumer acceptability and are basically well adapted to the tropics. Any improvements or breakthroughs in virus or other disease control would be immediately utilized by international research centers and in interested country programs.

In this critical area of disease and insect control, most of the technical expertise, motivation and facilities, as well as the tropical soil and climatic environment, already exist in Puerto Rico. The new legume project with the University of Puerto Rico will capitalize not

*CG -- Consultative Group of World Donors for Agricultural Research

**AVRDC -- Asian Vegetable Research and Development Center

only on its special competence in the field of virology but also on the widely recognized expertise in other diseases of the USDA scientists assigned to the UPR research team.

The major objective of this project is to investigate the nature and control of diseases of the tropics and subtropics (virus, bacterial, fungae, nematodes and microplasma) and related insects. Where possible, improved plant populations with specific or multiple resistance will be developed by the Puerto Rico team and made available directly to interested developing countries or through the international network. New breeding approaches will be employed, e.g., the use of chemosterilants and cytoplasmic male sterility to effect maximum recombinations in the segregating populations similar to what is being extensively accomplished in sorghum improvement and is well under way with rice, wheat and barley. Thus, there would be a strong interdisciplinary effort on disease and insect control involving primarily plant breeding and phytopathology.

The present estimate is that within five years the project will have made sufficient progress that a major part or all of this activity could be assumed by the responsible international centers (CIAT, IITA, ICRISAT, IRRI and AVRDC) or by some of the more advanced developing countries such as Colombia, Brazil, Nigeria and India. This progress will be in the form of improved varieties with superior disease and related insect resistance which have the potential for becoming economically competitive with the more popular and more extensively grown cereal crops.

Addendum (November 16):

The proposal as described in the following Project Statement was reviewed by the Inter-Bureau Technical Committee on October 17, 1972, and on November 13 it was reviewed and approved by RIGC as indicated in the foregoing Supplement. In accordance with the RIGC recommendations, TA/AGR is in the process of working out with Puerto Rico and the USDA details for a consolidated work plan and naming Puerto Rico University as the administrator of the project. Details on the work plan, managerial arrangement and unified budget will be provided to the RAC in advance of the January, 1973 meeting.

TA/AGR: SCLitzenberger:sad

PROJECT STATEMENT

Submitted: September 28, 1972
Amended*: November 16. 1972

A. PROJECT SUMMARY

1. Statistical

Project Title: Improvement of Tropical Production of Beans and Cowpeas Through Disease and Insect Control

New or Extension: New Project

Contractors: College of Agriculture, the University of Puerto Rico (UPR), Mayaguez, Puerto Rico and the U.S. Department of Agriculture

Principal Investigators: Dr. Julio Bird, Bean Pathologist
University of Puerto Rico

Dr. Walter Kaiser, Pathologist, Plant Breeder
Dr. Nader Wakili, Plant Breeder, Pathologist
U. S. Department of Agriculture

Duration: Five years (see Note below)

Total Estimated Cost: $1,715,705.

Funding by Fiscal Years:

1973 (6 mos)	-	$250,330**
1974	-	175,375**
1975	-	355,000
1976	-	365,000
1977	-	375,000
1978 (6 mos)	-	195,000

Project Manager: Dr. Charles Kreitenbach

Project Specialist: Dr. Samuel Litzenberger

* Page 1 only (see Addendum to foregoing Supplement).

** $250,330 for 18-month initial funding of UPR contract (Jan. 1, 1973 to June 30, 1974); $175,375 for 12-month funding of USDA PASA (July 1, 1973 to June 30, 1974). Costs are merged for subsequent years.

NOTE: Duration proposed by TA/AGR prior to RIGC review. At its meeting on November 13, however, RIGC recommended approval for three years, with further funding contingent upon a review of progress during the third year.

2. Narrative

One of the most promising ways of increasing protein for human consumption in the developing countries is through an increased production of edible legumes such as beans and cowpeas. They are high in assimilable protein and thus a good substitute for less readily available, more costly animal products. Beans and cowpeas are already common items in the consumption patterns of most of the Americas as well as many countries of Africa and Asia. Their more extensive use is limited only by a lack of adequate production. It is generally agreed that the most serious factors which have limited higher yields and greater production in this group of crops are diseases, nematodes and insect pests. In fact, diseases and pests have continued to so reduce the yields of these crops that in many areas they are now produced only for subsistence.

Preliminary studies have indicated that there are numerous cases of natural resistance to the major pests and diseases of the leguminous crops and that by the use of such selections in breeding programs present yields can be greatly increased. In Puerto Rico, for example, soybean crops grown consecutively throughout the year have produced aggregate yields of almost 10,000 pounds of dry grain per acre. Selected pigeon peas have yielded 4,000 pounds of grain over a five months period. There appears to be little doubt that with control of diseases and insects, bean and cowpea yields can approach these production figures provided necessary agronomic practices for land preparation, the use of fertilizers and soil amendment, weed control and improved plant nutrition can be made available.

The major objectives of this project are first, to screen natural populations of food legumes adapted to the tropics, particularly beans and cowpeas for natural sources of resistance to the major diseases and insects which limit their production. Where natural resistance cannot be found, a second major objective will be to investigate and develop suitable methods of disease and insect control. A further component of the project will be training support to prepare technicians who can extend the activitie financed under this contract to developing countries throughout the world.

B. EXPANDED NARRATIVE STATEMENT

1. Project Description and Background

Since 1963, A.I.D. has had a PASA with the USDA on edible legume improvement, first in Iran, then in India and Puerto Rico. As a result of this work, considerable progress has been made in the improvement of these crops in Asia. The work is being continued by the Governments of Iran and India and by the FAO. In Puerto Rico the USDA project has released two virus resistant beans. One is resistant to the principal virus of red beans and the other resistant to the principal virus of black beans. Resistance has already been found to stunting virus and to golden yellow

virus, two major viruses transmitted by the white fly in beans and cowpeas. Resistance has also been found to a beetle-transmitted virus disease of these crops. Twenty lines of beans and cowpeas are now under propagation for release as varieties with resistance to one or more of these virus diseases.

We now intend to discontinue the A.I.D./PASA agreement which has been maintained with the USDA and to initiate a cooperative USDA-University of Puerto Rico project on bean and cowpea improvement at Puerto Rico. The activities currently underway under the PASA in Puerto Rico will become an integral part of the cooperative project.

2. Significance to A.I.D. Objectives

A key project area of A.I.D. assistance has been the improvement of basic food crops with emphasis on high quality and higher level assimilable protein. Research activities currently are supported for the development of improved protein in wheat, maize and sorghum. A.I.D. recognizes that inherently grain legumes are a better source of plant protein for human consumption than the cereals. They contain 20 to 40 percent protein compared to the cereal grains which average only 1/4 to 1/2 this amount. Although there exists a great potential for increasing present day yields of these crops, very little research has been done on them as compared to that in the cereal crops. For this reason, A.I.D. considers research in the beans and cowpeas to be of very high priority. This work will comprise a segment of a program in legume development which is part of the responsibility of the international centers.

3. Relation to Existing Knowledge

The grain legumes constitute a major group of food crops on which relatively very little research has been undertaken. While the plant breeders continued to stress research on the improvement of such cereals as wheat, rice, corn and sorghum, the grain legumes were to a very large measure neglected. In part, this has been a consequence of the fact that the cereals always constituted a basic food for most people while the grain legumes have been considered as a supplement in their diets.

Throughout most of the tropics a cereal is the major food crop. This is followed, whenever possible, by a secondary planting of a grain legume. The grain legumes are generally treated as catch crops which make use of that part of the growing season in which the land is otherwise not employed. As such little effort is expended on their culture; fertilizers and biochemicals to control pests are rarely employed. In fact, farmers in most parts of the world feel that any production they may obtain from these crops is a bonus which they would not otherwise have enjoyed. Thus, traditionally farmers have been satisfied with poor yields and have done little to improve them.

Only recently has the importance of the grain legumes attained widespread recognition. This has resulted from the realization that in much of the world protein starvation has become more critical than caloric hunger. The former has been linked to a reduction in the vitality of people and the ability of small children to exploit their full learning capacity. The need to increase the production of grain legumes in the developing countries has, as a consequence, assumed a vital importance.

Present production levels in this group of crops are often less than one-fourth what preliminary trials indicate they are capable of yielding when modern farming practices are introduced. For this reason, there is little doubt that a high pay-off can result from A.I.D.'s support of a bean and cowpea improvement program. The biggest constraint to production are diseases and insect pests. Thus, research directed toward their control is of highest priority.

4. Relation to Other Research

The new cooperative project with the University of Puerto Rico and the USDA will differ from the current A.I.D./PASA agreement with the USDA for grain legume improvement in that it will attack a narrower sector of the problem more intensely. The USDA PASA has dealt with a considerable number of edible legumes grown in Asia, Africa, the Latin American countries and in the U.S.A. In large measure, it was a project for the collection and screening of the principal edible grain legumes so that they might be conserved for future breeding programs. Only a small part of that program consisted in the development of resistance to diseases and pests. It is this part of the work that will be continued and strengthened under the new contract. The Asian portion of the PASA program was taken over by the Indian Government in 1968 and Iranian Government in 1971. At that time, a collection of several thousand edible legume selections was packed and shipped to the USDA seed storage facilities at Fort Collins where it is conserved as a germplasm resource. It will be available to this cooperative project.

Now it is intended that A.I.D. research under the new project will deal with only the two crops: beans and cowpeas. The principal thrust of the new project will be to screen for lines resistant to the major diseases and pests of these two crops. Resistant varieties will be selected and recombined in order to obtain materials with multiple resistance for distribution to and use by cooperating A.I.D. Missions, developing countries and the international research institutes. Because diseases and pests of beans and cowpeas are the primary causes for their low production level, these problems must be attacked before other components in a packaged program for increasing yield (e.g. fertilizer usage and controlled agronomic practices) can prove effective. For that reason, it has been concluded a concentrated effort such as described above can provide the maximum return for A.I.D. input into a legume development effort.

The new project, titled "Improvement of Tropical Production of Beans and Cowpeas Through Disease and Insect Control", will be managed as part of the A.I.D. key effort for the development of basic food crops with improved protein quality and content. As such, it will be coordinated with A.I.D.'s ongoing research contracts in this area, namely projects for the development of high quality, assimilable protein in the cereals (wheat, sorghum and maize).

At the present time, the Consultative Group on International Agricultural Research (CG) is studying how adequate attention can best be given to the major food legumes: soybeans, beans, cowpeas, pigeon peas, chickpeas, lentils and mung beans. It is A.I.D.'s belief that the University of Illinois, because of its vast experience with the crop, may best be designated as the international center for soybean research. This position is encouraged by the Technical Advisory Committee of the CG. It now appears that existing international research institutes (CIAT, IITA and ICRISAT*) will develop major research programs on chickpeas, pigeon peas, cowpeas and beans.

The proposed bean and cowpea project shall constitute an A.I.D. contribution to the worldwide legume development program. It will be closely integrated with research on the grain legumes carried out at the international research institutes, as well as by regional and national research centers, and it is intended to complement their research programs. Much of the proposed work is of a more fundamental nature than that normally done at the international research institutes.

5. Proposed Work Plan

a. Scope of Work

It is the intent of the A.I.D. contractual arrangements with the University of Puerto Rico and the USDA to focus on a well defined sector of the international research and outreach network in grain legume improvement. This is the screening of bean and cowpea populations for lines resistant to disease (fungal, bacterial and virus), nematodes and insect pests, and the recombination of these lines into varieties which possess multiple disease and pest resistance. Also included would be irradiation to induce new mutations for resistance. Because resistance may not always be attainable, it is intended that the agreements include provision for investigations on other economic means of disease and pest control. The work contemplates the study of the biology of specific pathogens, nematodes and insect pests in order to determine at which phase of an individual deleterious agent's life cycle, biological controls, chemical controls or cultural practices can be most effectively used. The study of transmission of virus diseases by insect vectors will be a major effort. A concordant component of the agreements will be to train technicians who

*CIAT - International Center for Tropical Agriculture, Colombia;
IITA - International Institute for Tropical Agriculture, Nigeria;
ICRISAT - International Crops Research Institute for the Semi- Arid Tropics, India.

will be able to make use of improved bean and cowpea materials and improved practices for production in their own countries.

Germplasm lines of beans and cowpeas with multiple resistance will be made available to International Centers, USAID Missions and host country technicians for their particular use and breeding programs. It is recognized that the ultimate selection of germplasm materials and the adaptation of specific production practices will have to be accomplished under specific country and climatic conditions. The University of Puerto Rico and the USDA intend to cooperate with individual developing country institutions in this phase of the work.

As already stated under Section 4, above, this defined sector of legume research, which is more fundamental in nature, will constitute a part of the international research network for grain legume research. The work accomplished by the UPR/USDA project will be complementary to that of the international research institutes. It is anticipated that all or most of the project will be absorbed by one or more of the international centers as well as by stronger developing country research systems within five years. Thus, subject to unforeseen difficulties, this project would terminate by the end of 1977.

b. Work Plans

The work plans of the two cooperating institutions - the University of Puerto Rico and the USDA - are presented in detail for the initial 18-month period on pages 8 and 9. These plans reflect an apportionment of work according to the specialties in which each institution is best qualified. They provide for a cooperative effort in those activities in which they are to function jointly, i.e.: outreach programs such as the training of foreign students and linkage programs under which resistant materials will be tested in uniform nurseries abroad and released to cooperating agencies in the worldwide linkage system.

The University of Puerto Rico is well equipped to perform the laboratory culture of the different fungi and to study their biology. It is developing its facilities in the fields of nematology and insect control. For these reasons, the University's work plan emphasizes laboratory research on the races of viruses which are most virulent on beans and cowpeas and their vector-transmission relationships. It will work on biology of the more serious bacterial and fungi diseases, because through an understanding of their life cycles, it may be possible to determine the most practical means for containment of the disease. The University will also be responsible for research on disease and pest control by chemical means.

The USDA team has developed a strong capacity in the transmission of diseases observed in the field onto cultivated legume materials and in the screening of legume cultivars for disease resistance. On the PASA team, there is a skilled plant breeder. For that reason, the work apportioned to the USDA is, for the most part, the survey of fungal and

bacterial diseases which are seriously reducing yields in beans and cowpeas and the screening of the world collection for cultivars with resistance to disease infection. The USDA will be responsible for the breeding of resistant bean and cowpea varieties and the development of multiple disease resistant lines for distribution to international centers and institutes integrated in the worldwide bean and cowpea network.

The work of both the University of Puerto Rico and the USDA will be greatly facilitated by the fact that most, if not all, of the important diseases of grain legumes, including pathogenic nematodes, and insect vectors, are present in the Island's agriculture.

6. Research Methodology

The bean and cowpea activity will employ standard research procedures for the screening and identification of disease and pest resistant cultivars. Wherever it is possible to employ natural sources of infection, as for example in the case of nematodes, the screening prodedure will be effected utilizing natural populations. In most instances of disease resistance, where several subraces may exist, resistance to individual strains will have to be tested by means of artificial infection with laboratory cultured pathogens.

The UPR College of Agriculture is proficient in the study of transmission of virus diseases to plant materials by the use of insect vectors, and it maintains superior facilities for rearing these virus disease vectors as well as other insect pests. The University also maintains a well equipped virology laboratory and is able to identify different races of similar appearing viruses using modern serological techniques.

The USDA facility at Mayaguez is well equipped to study the biology of fungal and bacterial diseases under laboratory conditions and thereby evaluate their control by biological and chemical methods. The USDA staff is prepared to breed resistant varieties of high yielding, quality beans and cowpeas once resistant lines have been identified. As both crops are self-pollinated, breeding procedures are simplified and protection against cross pollination is not required. A standard backcross procedure is generally employed to transmit disease or pest resistant factors to otherwise desired plant types. By the backcross method, it is also possible to achieve multiple resistance in a single variety.

UPR College of Agriculture Contribution to Cooperative UPR-USDA Bean and Cowpea Project

I. Survey of virus diseases of edible and related wild legumes with regard to their transmissibility to beans and cowpeas.

II. Identification and characterization of viruses of edible and wild legumes, especially those transmissible to beans and cowpeas.

- a. Transmissibility
  - (1) artificial
  - (2) seed, soil
  - (3) insects
- b. Host range
- c. Physical and other properties
- d. Serological studies
- e. Morphology studies, via electron microscopy, etc.
- f. Vector-virus relationships
- g. Strains

III. Greenhouse screening of hybrids and selected varieties and lines, for resistance to insect-transmitted viruses.

IV. Study of insects associated with beans and cowpeas.

V. Yield and agronomy of selected lines, hybrids and varieties.

VI. Disease and insect control via chemical means.

VII. Study of nematodes in relation to beans and cowpeas.

III. Study effect of environmental factors on symptom expression and survival of virus affected legumes.

*IX. Outreach programs.

- a. Cooperation with other tropical institutions.
- b. Attendance at workshops, and local and international scientific meetings.
- c. Cooperative field trial studies and disease surveys in other areas,
- d. Publication of research results.

*X. Release of disease resistant lines.

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* Joint UPR-USDA activity.

USDA Contribution to Cooperative USDA-UPR Bean and Cowpea Project

I. Survey of fungal and bacterial diseases of edible and related wild legumes transmissible to beans and cowpeas.

II. Maintenance and distribution of germplasm collection at the Federal Experiment Station, Mayaguez.

a. Field testing.
b. Greenhouse testing with the exception of insect-transmitted viruses.

IV. Breeding for disease resistance, including studies on inheritance of disease resistance.

a. Lines with multiple resistance to different diseases.
b. Lines with multiple resistance to races or strains of the same pathogen.
c. Genetics of disease resistance.

V. Incorporating resistance to insects and nematodes into multiple disease resistant lines. (Support to be provided by UPR Departments of Entomology and Plant Pathology.)

VI. Studies on the effect of nutritional and environmental factors on growth, spread, pathogenicity and survival of fungi and bacteria pathogenic to beans and cowpeas.

*VII. Outreach programs.

a. Cooperation with other tropical institutions.
b. Attendance at workshops, and local and international scientific meetings.
c. Cooperative field trial studies and disease surveys in other areas.
d. Publication of research results.

*VIII. Release of disease resistant lines.

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* Joint USDA-UPR activity.

7. Researcher Competence

The USDA has a PASA with A.I.D. for grain legume crop development under which good progress has been made. The Department of Agriculture's competence is well known.

The UPR College of Agriculture's Department of Plant Pathology and Botany and the Nematology Section of the Department of Entomology are provided with spacious and functional laboratories for work in general plant pathology, serology, plant physiology, plant virology and nematology. Greenhouse space is available for the proposed research including five large units for plant pathology and nematology as well as air-water cooled greenhouses for rearing insect pests and other virus-transmitting insects. The staff of the College of Agriculture includes more than 100 scientists with the Ph. D. degree. The College proposes to make available a professional staff of 10 senior scientists to the contract, all of whom have already earned a well-merited reputation for their research in virus disease transmission. In addition, the Experiment Station system of the College of Agriculture maintains six substations in different ecological regions of the island where comparative trials may be run on disease and insect resistant materials.

8. Contribution to Institution Building

The University of Puerto Rico shares a common language and cultural heritage with the Latin American republics, and therefore is able to relay to those countries the highly developed agricultural technology of North America, without encountering barriers imposed by a different language and tradition.

The Island of Puerto Rico though comparatively small in area has a varied range of soil types, climatic conditions and plant diseases representing many of those found throughout the tropics. Therefore, it provides an agricultural laboratory in which students from other tropical countries will find conditions similar to theirs. Participants working in the bean and cowpea program will, as a consequence, find that as they learn specific measures and principles of disease control developed in Puerto Rico they will have broad applicability back home.

More important than the similarity of culture and that of the ecology of the large number of developing countries throughout much of the world, however, is the fact that here the student will find a modern university at which to study and experience the impulse of a country which has undergone the transition from a primitive agriculture to modern farming methods in relatively few years.

One of the functions of the University of Puerto Rico and the USDA will be to provide the opportunity to train students from all the continents, but particularly from the Americas where beans and cowpeas are

the more important grain legumes of the diet, and to send them back home prepared to utilize the information they have acquired to improve the production of these crops in their own countries. It is intended that after their training in the program, these men and women will return to their institutions and become the cooperators through whom new materials developed in Puerto Rico may be made use of and adapted to local conditions.

9. Utilization Plans

It is intended that new improved disease and pest resistant varieties will be multiplied and made available for extended use in the developing countries. This applies equally for new methods of pest control. Of course, in many instances it will not be possible to use the new materials exactly as they have been received. However, the adaptive research required to render them useful back home should be relatively uncomplicated. Generally, this will require such techniques as breeding new factors isolated for resistance to an endemic disease into the preferred variety of a specific country. It is the type of adaptive research which participants who have prepared at Puerto Rico will be prepared to do.

There should be no difficulty in disseminating improved varieties of beans and cowpeas. Experience has shown that when farmers are provided with new crops whose production is dramatically better than the varieties they have been accustomed to, the transition is rapid and sells itself.

10. Budget Analysis

The budget presented for the USDA (Attachment A) is for a 12-month period and is to commence upon the termination of the present PASA agreement on June 30, 1973. The budget presented for the University of Puerto Rico (Attachment B) is for an 18-month period and is projected to start on January 1, 1973. This will enable both the budget of the USDA PASA and that of the University of Puerto Rico to be funded simultaneously after June 30, 1974.

11. Internal and External Reviews

Due to the late receipt of the present proposal, it has not been possible to hold a review of the project with the Regional Bureaus prior to the preparation of this document. SA/AGR intends to schedule such a review prior to the RIGC meeting. RIGC will be advised of the results. This approach, however, has been discussed with our Regional Bureau counterparts over the last year.

12. Proposing Office General Evaluation

This project is rated as of very high priority. It is considered that research on the grain legumes should be carried out in conjunction with the ongoing projects TA/AGR has sponsored on the improvement of protein content in the cereals: corn and sorghum at Purdue University and wheat at the University of Nebraska.

The protein content available in legumes such as beans and cowpeas is more than twice that in the best cereals such as Opaque-2 corn. Our goal is to increase the protein available in the diets of the people of the developing countries. It is a project which we consider must not be delayed.

Attachments:
a/ -

Omer J. Kelley, Director
Office of Agriculture

Charles Breitenbach
Charles Breitenbach
Project Manager

Attachment A

12-Month Budget for USDA Activity (To start July 1, 1973)

	Total
Salaries	
Present Staff	
1 Plant pathologist	26,000
1 Plant pathologist - Breeder	25,000
3 Research technicians	26,000
2 Crop research helpers	10,000
1 Clerk typist	5,500
L/A Labor	4,500
	97,000
Proposed Additional Staff	
2 Crop research helpers	10,000
Other Services (Maintenance)	
Vehicles, Tractors and other machines	2,300
Irrigation and water facilities	800
Greenhouse and other facilities, housing supplies and equipment for project	4,900
	8,000
Travel	
Local (within Puerto Rico and the U.S.)	1,200
International	10,000
Home Leave and TDY	2,300
	13,500
Expendable Supplies and Materials	
Glassware, laboratory chemicals and supplies fungicides, insecticides, fertilizers, seed envelopes, paper and plastic bags, etc.	5,000
Equipment	
Seed storage and seed cleaning facility	15,000
Other non-expendable equipment items, such as pH meter, Bod incubator, balance, shaker, irrigation pipe, sprayers, etc.	4,000
	19,000
Total Budget (without overhead)	152,500
USDA Overhead (15%)	22,875
	$ 175,375

Attachment B

18-Month Budget for University of Puerto Rico (To start January 1, 1973)

	Percent Of Time	Total (18 mos.)
Salaries		
Present Staff		
Phytovirologist	75	22,500
Phytovirologist	50	12,000
Associate Biologist (virus)	100	15,000
Entomologist	50	12,000
Plant Pathologist - Nematologist	50	12,000
Laboratory Assistant	100	9,000
Stenographer	100	9,000
Proposed Additional Staff		
Plant Pathologist	100	21,000
Laboratory Assistant	100	9,000
Research Assistant	100	12,000
Hourly Wages		
Laborers - several part-time, equivalent to two men full-time for 18 months		12,000
	Total Salaries	145,500
Indirect Costs (46%)		66,930
Staff Support		
Travel Expenses		12,000
Visiting Scientists, Students and Technicians		5,000
Equipment		
2 Mini-greenhouses		2,400
1 Insectary		3,500
1 Percival chamber		4,500
Supplies and Materials		9,000
Contractual Services (e.g., feed trials)		1,500
	Grand Total	$ 250,330

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INFORMAL MINUTES OF RESEARCH AND DEVELOPMENT COMMITTEE MEETING
November 25, 1975

Can you get

Project: Improvement of Tropical Production of Beans and Cowpeas Through Disease and Insect Control (extension), 3 years, $1,157,000.

Contractor: University of Puerto Rico

Project Manager: Keith Byergo, TA/AGR

Discussion Highlights:

Norman Cohen, PPC/DPRE, questioned the pipeline situation for this project. It now contains $392,000 of unliquidated funds which is greater than 2 years at the current expenditure rate. What is the need for new funding at this time? Is the timeing and the amount realistic? Keith Byergo the project manager, commented that the large pipeline is due to expenses for electron microscope accessories which are awaiting a source waiver, and USDA restriction on travel of USDA personnel. Robert O'Brien, CM/COD stated that the fiscal pipeline is reviewed and appropriate fiscal adjustments in the contracts extension are made during contract negotiation.

Norman Cohen stated that the purpose in the Log Frame does not agree with the PP and questioned the evidence on progress towards the project goals of 3 years ago and the anticipated goals for the extension. How do the findings get to the farmer? George A. Harwell, ASIA/DP, commented on the need in the PP for yearly targets as a basis for measurements in evaluation and the need for acceptable evaluation criteria. Also the Log Frame should be revised to reflect anticipated accomplishments rather than only past accomplishments. Keith Byergo pointed out that the project is considered to be successful in the virus disease analyses. The University of Puerto Rico reports on a calendar basis, and since 1975 is not completed or reported, references in the Log-Frame to 1974 may be appropriate. Carl Fritz pointed out that information dissemination plans are built into the design of most projects, and, in addition, external support for appropriate utilization is available. Dr. Long commented that he believed the responsibility for local utilization of research results belongs in the LDC; the researcher should not be unduely encumbered with utilization and information tasks. John Balis, NE&A/TECH, recommended use of external evaluation reviews for all major investments. Also, the PP would be improved if it included a utilization phase. This would assist the Bureaus in determining what the research results are and how to utilize these results in their projects.

Woody Leake, AFR/NAR, questioned the (1) reported fundamental work under this contract as contrasted to the adaptive work of the international institutes and (2) possibly duplicative work on nematodes with that of North Carolina State University. Answers given were that the work under this contract is

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PROJECT STATEMENT

PROJECT SUMMARY

1. Statistical

Project Title:	Improvement of Tropical Production of Beans and Cowpeas Through Disease and Insect Control
New or Extension:	Extension
Contractors:	College of Agriculture, the University of Puerto Rico (UPR), Mayaguez, Puerto Rico. Mayaguez Institute of Tropical Agriculture, U.S. Department of Agriculture, Cooperating.
Principal Investigators: Proj. Leader,	Dr. J. H. Lopez-Rosa, Plant Pathologist; ✓ Dr. Carlos Cruz, Entomologist; ✓ Dr. Pedro Mellindez, Plant Pathologist - ✓ Dr. Julio Bird, Bean Pathologist - ✓ University of Puerto Rico; Dr. N. G. Vakili, ✓ Pathologist, Plant Breeder, Dr. G. F. Freytag, ✓ Plant Breeder - U.S. Department of Agriculture.
Duration:	January 1, 1973 - October 31, 1978
Funding to date:	$ 800,000 thru FY 75
Total Estimated Cost:	$ 1,157,000 (thru FY 78) X
Funding by Fiscal Years:	

1976	--	340,000
1977	--	395,000
1978	--	422,000

Project Manager: Keith M. Byergo

1,157
800
357

Narrative:

During the initial two years of this project, the University of Puerto Rico (UPR) staff in conjunction with the USDA Mayaguez Institute of Tropical Agriculture (MITA) staff have established a sound base for research in tropical bean and cowpea culture. With competent staff and facilities, they are in a position over the next three years to provide varieties of beans and cowpeas that have commercially accepted quality, and due to inbred multi-resistance to prevalent insects and diseases of Latin America, greatly increased yields. Already released varieties are being commercially produced and are in general use in the national and international grain legume development programs of the region.

As detailed in the initial project statement, legumes are the principal protein source of the target area, the LDCs in Central and South America and the Caribbean. Further, developments in Puerto Rico are often applicable and useful in Asian and African Grain legume work.

Research is in progress in the areas that follows: (1) surveys for and studies to properly characterize virus diseases and develop simplified methodologies to enable the evaluation of germ plasm for resistance to the etiological agents of the diseases in Tropical America, (2) evaluation of chemicals for the control of disease agents and insects, (3) surveys of nematodes, (4) evaluation of germ plasm for resistance to diseases and insects, and (5) breeding work to produce high yielding lines and cultivars with multiple resistance to diseases.

Work on the above mentioned aspects is conducted at the Agricultural Experimental Station of the University of Puerto Rico, Mayaguez Campus, at facilities located in Rio Piedras and Mayaguez and in various substations; in MITA at Mayaguez and regional substations; and cooperatively in various Central American countries; at CIAT, Cali, Colombia and the University of Wisconsin.

The current internationally recognized competence of the University of Puerto Rico in the field of grain legumes vouches for the success of the project in this area. Newly released varieties, consultancies, graduate students, seminars and published papers, the Workshop on Tropical Disease of Grain Legumes and the resulting book, all have attested to the excellent capability of the project institutions and their staff.

2. Research Purpose and Expected Products:

Purpose:

The major objective of this project is to study the insect and disease problems effecting production of grain legumes in the tropics and to develop and disseminate means of control. Also of high priority is improving grain legume research and production competence in LDCs.

Expected Products:

1. Multiresistant varieties of beans and cowpeas for commercial production, suited to the various ecological conditions in tropical and subtropical areas will be the principal product of this research.

2. A germ plasm bank of a size and variety to constitute a major source of breeding material for cooperating national and international programs.

3. An experienced and well equipped staff at UPR with internationally recognized competence in grain legume insect and disease control and a bank of knowledge available to other institutions involved in like work. This will constitute a resource to continue the research necessary to maintain viable lines of grain legumes against the evolution of new diseases and insects. It is foreseen that the current grain legume programs of CIAT, IITA, ICRISAT and major national programs will benefit sufficiently from the work initiated under the AID/UPR contract to continue the necessary research and development following completion of the contract.

4. A staff of newly trained scientist who will constitute a nucleus of expertise in developing competent national programs in grain legume production.

5. A system of linkages between institutions involved in grain legume research that will assure continuing cooperative efforts in the exchange of research and production technology.

3. Significance and Rationale for the Research:

A key project area of AID assistance has been the improvement of basic food crops with emphasis on high quality and higher level assimilable protein. Research activities currently are supported for the development of improved protein in wheat, maize and sorghum. AID recognizes that inherently grain legumes are a better source of plant protein for human consumption than the

new cereals. They contain 20 to 40 percent protein compared to the cereal grains which average only ¼ to ½ this amount. Although there exists a great potential for increasing present day yields of these crops, until the initiation of this project little research has been done on tropical grain legumes as compared to that in the cereal crops. Commercial planting of newly developed project bean varieties have produced 2 tons per acre in Puerto Rico. This compares with average yields of 500 to 600 pounds per acre.

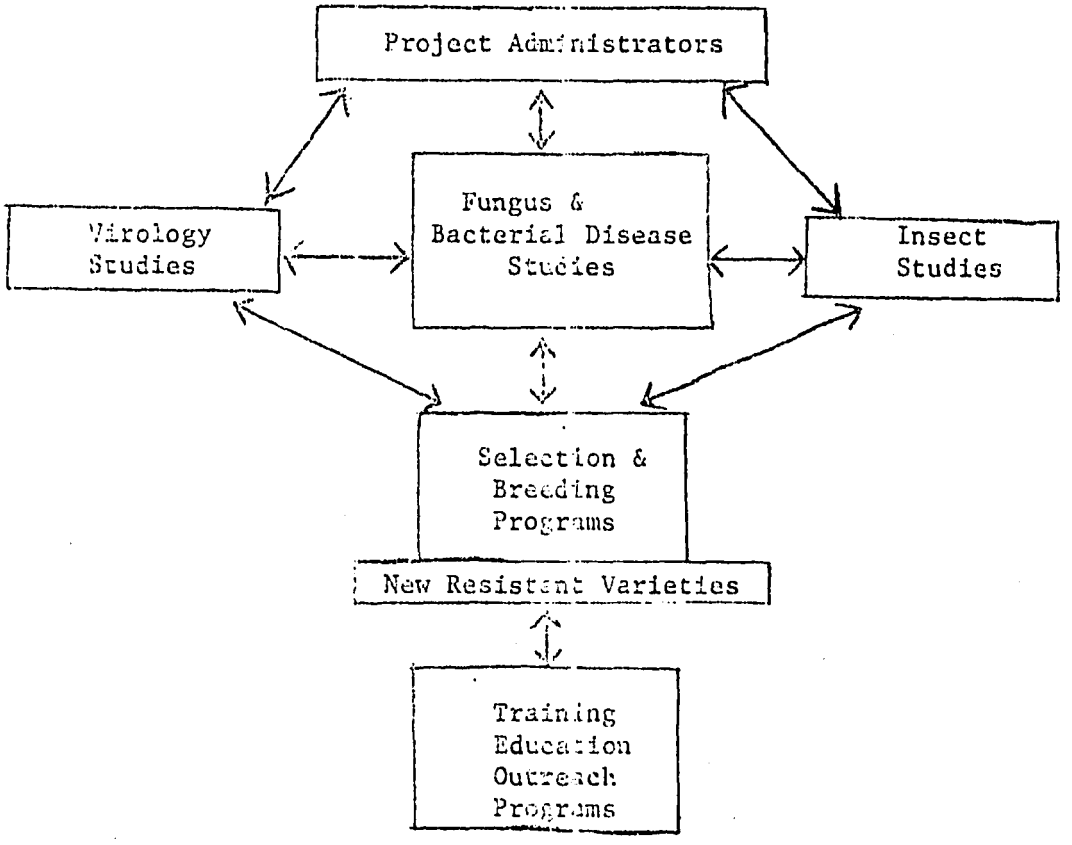
In much of Latin America, Africa and Asia grain legumes are the second largest food crop both in areas and tons of production, and the primary protein source. Population increases in LDCs also increase aggregate demand for grain legumes. More efficient production, other things being equal, mean a higher return to the small farm producer. For this reason, AID considers research in the beans and cowpeas to be of very high priority.

AID through it's initiative can make a significant contribution in the basic research and training necessary for national programs to develop. The first two years of the project have defined the problem and indicated answers. This proposed three-year extension would develop the bank of knowledge and technical expertise from which national and regional programs could build.

This two-year involvement of the University of Puerto Rico in cooperation with USDA has been a productive period with advances being made on all fronts to increase grain legume yields particularly beans and cowpeas.

Building on staff, facilities and technical information that has been developed over this period, it is reasonable to assume that commercially acceptable varieties of higher yield and protein quality potential will evolve from research conducted during a three-year extension of the contract.

Schematically the project functions as follows:



4. Plans to Coordinate and Link Research:

The extension of the bean and cowpea project shall constitute an AID contribution to the worldwide legume development program. It will be closely integrated with research on the grain legumes carried out at the international research institutes, as well as by regional and national research centers, and it is intended to complement their research programs. Much of the proposed work is of a more specialized nature than that normally done at the international research institutes. In this way a major contribution will be made to existing adaptive and production type programs.

Following are the international institutions and grain legumes for which they have international network responsibility:

Crop	Responsible Institution
Pigeon peas	ICRISAT - India
Chickpeas	ICRISAT - India
Dry beans	CIAT - Colombia
Cowpeas	IITA - Nigeria
Mungbeans	AVRDC - Taiwan
Soybeans	USA - University of Illinois

It is with the institutions as well as with major national programs in Colombia, Honduras, Mexico and Costa Rica that the project staff maintain close linkages via seminars, workshops, consultations and research data and germ plasm exchanges. The workshop held at Mayaguez and one scheduled in Colombia, December 1st, 1975 on disease and insect control of grain legumes are examples of the close coordination fostered by project staff.

5. Plans to Facilitate Utilization of Research Results:

In addition to the above listed project linkages with other national and international programs, the publication of research findings and seminar and workshop proceeding, graduate students from LDCs in Central and South America have been assigned as research assistance to project staff. These students will form a nucleus in the home country for the dissemination of research information and establishing grain legume programs.

Within Puerto Rico the University extension specialist and village staff are kept informed of project findings and supplied with new germ plasm for adaptive research and demonstrations to local bean growers. As progress is made in the development of improved varieties greater effort will be made on outreach programs. The major contribution to date has been in research methodology and breeding programs.

6. Management Considerations:

Non-contract funded contributions comprise a sizeable input into the project. These consist of two USDA staff members, a plant pathologist and a plant breeder who work full time on the plant breeding aspects of the project. Also two members of the UPR staff make significant contributions to project research from their work on cultural practices and insect resistance Their studies are conducted on the more promising cultivars at the regional research stations of Isabela and Lajas.

Regular on site evaluations using non-project staff from USDA, regional bureaus or universities are planned. This has been the past policy and has been beneficial to the project as well as broadening the base of detailed information on the project.

Project leadership on site is provided by a UPR staff member. He is responsible for maintaining close coordination and communication between the MITA staff and UPR staff. With staff at Mayaguez, Rio Piedras and at regional stations this becomes a major and essential activity. Nonproject activities of the UPR are closely related and supportive of project research and must be incorporated and considered in analysis activities. The USAID project manager can be helpful in this coordination activity as well as assist in coordination with national and international centers.

7. Technical Review:

Yield comparisons of traditional varieties with newly developed disease and insect resistant varieties have shown a three-fold increase in yield where the nonresistant varieties are only partially infected with prevalent disease and insect pests. Heavy infection can result in no yield in non-resistant varieties. Having found resistant genes in certain cultivars, the problem now is to incorporate a number of resistant genes in stable commercially accepted varieties thus providing multiple resistance along with high quality and yield.

The original PASA with USDA made a start with research on grain legumes in India and Iran. The more difficult tropical environment is now being researched under the UPR/AID contract. In addition to international programs at IITA and CIAT, a number of Central and South American national programs are also being established.

The work in Puerto Rico is currently more extensive therefore work being done there in coordination with other national and international programs will be cited as an example of the current state of tropical grain legume research. This will be reported under five headings: Virus, Fungi and Bacteria, Entomology, Nematology, and Breeding.

A. Virus Diseases

The small group of virus workers in the project staff has been able to characterize, beside many other phytopathogenic viruses, 7 different whitefly-transmitted agents, determining their relative effect on important crops such as beans, cowpeas, and other valuable legumes. On this account Puerto Rico has become an important center for scientists endeavoring to solve problems relative to virus diseases of legumes (particularly rugaceous maladies). The methodologies developed by the group in connection with the establishment and maintenance of stock cultures of Bemisia tabaci and mechanical inoculation of bean plants with rugaceous (whitefly-transmitted) viruses have enabled scientists to adequately study similar disease agents of legumes in other parts of the tropical world. The fact that many of the rugaceous diseases have been properly characterized will make the job of identifying these (through the proper use of diagnostic plants and indicators) an easier task for others.

B. Fungus and Bacterial Diseases

The major research achievements during 1974 are as follows: foliar diseases of cowpea (cv Early Ramshorn) were effectively controlled by the fungicides benomyl, mancozeb, dinocap and chlorothalonil. Dosages of

benomyl as low as ¼ pound per acre applied biweekly were enough to prevent infection by Erysiphe polygoni, the causal agent of powdery mildew, and by the fungi Cercospora canescens and Corynespora cassiicola, causal agents of leaf spot and target spot, respectively. Yields as high as 1,925 pounds per acre were obtained when higher dosages of benomyl, chlorothalonil and mancozeb were employed. Dinocap was highly effective against powdery mildew during the dry season, but failed to protect the plants during rainy weather.

The systemic fungicides Plantvax and Triforine at the rates of 2 and ½ pounds per acre, respectively and mancozeb at the rate of 1 pound per acre protected the foliage of bean cultivars Blanca del Pafs and Bountiful against rust caused by Uromyces appendiculatus.

Both, Kocide 101 (copper hydroxide) and Copper 53 (tribasic copper sulfate) at the rate of 1 pound per acre were very effective in controlling common bacterial blight (Xanthomonas phaseoli) of bean cultivar R-19, as indicated by the low disease indexes evident on this cultivar when exposed to both fungicides. No significant differences in yields were detected among fungicide-treated and control plots due to the fact that bacterial invasion occurred after pods were already developed.

Exchange of information internationally, was accompanied by a "Tropical Diseases of Grain Legumes Workshop" held in Puerto Rico in June 1974. A book has recently been published covering the finding of the workshop edited by Dr. Julio Bird of the project staff and Dr. K. Maramorosch, Project Consultant.

C. Entomology

The most outstanding findings to date have been the identification of the most important insects attacking beans and cowpeas and the evidence of resistance or tolerance in some cultivars to the major insect pests. Evidence was found of resistance to the bean leafhopper, Empoasca fabae, and to the cowpea weevil, Chalcodermus abeninus which are the most damaging insects of these crops in Puerto Rico and possibly in other tropical regions. Preliminary observations also suggest resistance in beans to the bean weevil, Acanthoscelides obtectus.

Other insects found on cowpeas were the vegetable leafminer, Liriomyza munda; pod borers, Maruca testularis and Eitella zinckenella; aphids and cutworms. Other insects observed on beans were the vegetable leafminer, Liriomyza munda; the bean beetle, Cerotoma ruficormis; (also on cowpeas) the sugar cane weevil, Diaprepes abbreviatus; the lesser cornstalk borer, Elasmopalpus lignosellus; the leaf roller, Urbanus proteus and other leaf tiers.

Besides the cowpea weevil and the leafhoppers, other insects of potential economic importance are the leaf miner, the bean beetles and the podborers. Populations of these insects should be observed carefully since an outbreak of any of them could reduce yields significantly.

Twenty-six lines of beans and cowpeas were field tested for the effectiveness of insecticides in controlling distinctive insects. Conclusive results will require further testing. Natural resistance and local predators are also being screened to reduce dependence on chemical control.

Evidence of resistance to leafhopper was found in eight selections of white beans. Colored beans however proved very susceptible. Resistance to cowpea weevil was also noted. All of these observations will require continued work and screening before varieties can be released for commercial production.

These findings will enable us to concentrate our research efforts to obtain resistance and to develop other measures to control the most important insects. Selected germ plasm shown to be resistant or tolerant to insects will be provided to the plant breeder.

D. Nematology

Work on the nematology phase has been limited to preliminary surveys. Nematodes representative of 12 genera of parasitic or suspected phytoparasites were found associated with beans and cowpeas at the Isabela Substation, and 7 genera with 28 cowpea accessions at the MITA farm, also at Isabela.

With the assignment in FY 76 of a nematode specialist from Canada on a year's sabbatical leave to MITA, it is expected that cultivars with resistance to known nematodes will be identified.

E. Breeding Program

The bean breeding has been dependent on the recuperation of natural field hybrids occurring from flower visitation by the carpenter bee (Xylocopa brasilianarum).

This technique of using carpenter bees to cross-pollinate normally self-pollinating beans has resulted in crossbred lines with rust and virus

resistance, day length insensitivity, better climatic adaptability and increased yield. Screening of the International Cowpea Disease Nursery has resulted in improved cowpea mosaic virus resistance.

Present emphasis is being placed on obtaining controlled manual crosses in the greenhouse for specific gene transfer and for the formation of an intercrossing population or gene pool of multiple disease resistant lines. Preliminary results indicate fairly high fertility (from 40-70% pod set) from the manual crossing, depending on the parents used. Of the 11 parents in use for the population formation, the red bean line 15R-148 has shown exceptional fertility both as a male and female parent. The use of a manual procedure for recombining resistant germ plasm now offers great promise for accelerating the bean improvement work.

The germ plasm collection has been increased with the addition of 566 new lines this year. This greatly broadens the base of parent stock for breeding programs and the selection of desirable plant characteristics. This will lead to cooperative testing with other regional institutions to increase yield, quality and resistance to insects and diseases prevalent in Latin America and the Caribbean.

Research Findings:

(1) Virulence Study of Xanthomonas Isolates.

A virulence study with Xanthomonas isolates indicated 14 Vigna unguiculata P.I. accessions were susceptible to Xanthomonas phaseoli (American

Type Culture Collection #9563), the causal organism of the common bacterial blight of beans. These inoculation studies suggested that: (a) culture #9563 was a mixture of X. phaseoli and X. vignicola, (b) it was contaminated with X. vignicola during increase, (c) X. phaseoli mutated to X. vignicola in passage through V. unguiculata accessions, and (d) it contains factors for virulence against certain V. unguiculata genotypes.

Inoculation test indicated that P. vulgaris gives primarily a leaf blight symptom while V. unguiculata produces stem canker symptoms. These two types of symptom development occurred irrespective of the Xanthomonas source.

Preliminary trials suggest that "Fuscans" type isolates lose their capacity for pigment development when passed through susceptible V. unguiculata accessions.

(2) Disease Resistance, Yield and Adaptability Trials with Beans

a. Resistance of locally grown cultivars

A number of final selections and trials were conducted on the adaptability, agronomic characteristics and disease resistance of bush beans for cultivation in Puerto Rico. This work was started in cooperation with Dr. Marcial Rico-Ballester, Horticulturist, Lajas Substation. Varieties Bonita, Galana, Colorada del Pais, and French Horticulture were recommended for cultivation in Puerto Rico. The extensive work on the selection of adaptable bush beans resulted in the selection of seven cultivars which were grown for replicated yield trials during 1975.

b. Red Bean Trials

From a total of 1,898 lines in 1970, the final screening of the red bean lines resulted in 28 selections in 1974. The screenings were done for both disease resistance and yield. These selections will be subjected to replicated yield trials.

The most widely resistant cultivars were Ecuador-299 and Mexico-235. Both cultivars are highly sensitive to daylength. Selection 15R-148 is a rust resistant, CBMV susceptible, field resistant to soil-borne diseases, daylength insensitive, moderate to high yielding, dark red Mexican, dry bean cultivar that could serve as an important cultivar for breeding red bean adaptable to tropical lowlands.

The most important diseases in descending order of their importance were Rhizoctonia root rot and stem canker, southern blight, ashy stem blight and CBMV.

Sensitivity to daylength and temperature, and resistance to diseases were some of the most important factors affecting the yields of beans under the lowland humid tropical conditions.

c. Black Bean Trials

Soil-borne pathogens caused severe loss of stand among the susceptible cultivars during the rainy summer season and were a limiting yield factor in beans.

Bacterial blight is a major foliage disease during the wet season. Due to absence of effective chemical control it was difficult to estimate the loss due to this disease.

Whitefly transmitted viruses (WFTV) caused severe loss in yield when infection occur prior to inflorescence. However, WFTV were not a limiting factor for yield, if attack occuured after pod set.

There was a distinct and significant difference in field susceptibility of bean cultivars to WFTV. Cultivar Venezuela 63 was disease-free while cultivar 51051 was 34.8% diseased. Also, golden yellow mosaic incidence was five times higher than Rhynchosia mosaic incidence.

The results of a black bean yield trial indicated that cultivars Mexico-309, 15R-55, 15R-42, Jamapa and 71-1R-113 had the highest yields among 12 tested. It was interesting to note that after 4 years of screening and breeding the advanced breeding lines developed in Puerto Rico (15R-55, 15R-42 and 71-1R-113) equaled the yields of the best advance line and commercial cultivar in Central America. Further the new Puerto Rican varie have superior insect and disease resistance as compared to the other two variet

Bean cultivars varied in their level of susceptibility to web blight. Cultivar 15R-55 had the highest tolerance followed with Mexico-309. However, the latter cultivar, under field stress due to diseases and climate, has a tendency to develop flat seed.

Cultivar 15R-55 proved to be an outstanding candidate for release as adaptable, high yielding and disease resistant tropical black bean with an attractive seed form.

d. Bean Rust Resistant Trials

Field trial observations and data suggest that the following rust resistant cultivars La Vega, Jamapa, 15R-55, 15R-66, 71-1R-136-BK, and 15R-292 are good candidates for breeding adaptability, multiple disease resistance, and high yields in beans for the lowland tropics.

e. International Rust Resistant Tests

On April 13, 1973, a group of 22 rust resistant bean cultivars were sent to ten different countries for tests against endemic races. Up to date data from five countries have returned. The summary of these data shall be presented in the next annual report.

Some of the outstanding materials from these trials were:

- Cultivar PR-S-70-15R-42-1-BK was the only entry resistant to all endemic races in Southern Brazil.
- Cultivars PR-S-70-15R-55-BK, 15R-167-4-BK and PR-H-71-1R-113 were immune to rust races studied at Beltsville, Maryland.
- Cultivars PR-S-70-15R-87-BK, 15R-277, PR-H-71-1R-63 and 1R-69 were highly resistant to rust races in Colombia. Cultivar 15R-87-BK was chosen as one of the parental lines in breeding high yielding disease resistant beans.
- In Australia, 12 of the 22 cultivars were resistant to all endemic rust races. Cultivar PR-S-70-15R-87-BK was used in a number of crosses. The analysis of data has indicated five factors for rust resistance. Cultivars PR-S-70-15R-210-BK and 15-R-66-1-BK were included in the rust nursery trials.
- In Costa Rica cultivars PR-S-70-15R-87-BK and 15R-277-BK were resistant to endemic races in five different locations.

(3) Cowpea Disease Resistance Trials

a. Horticultural (Yardlong) Cultivars

Disease screening tests indicated that yardlong cultivars (Vigna unguiculata var. sesquipedalis) were highly susceptible to a wide range

of diseases. Selections were made for agronomic and horticultural characteristics and selected lines were tested in replicated trials. This work is continuing and the best agronomic types will be bred for disease resistance.

b. International Disease Nursery

In cooperation with International Institute of Tropical Agriculture, Ibadan, Nigeria, 104 cowpea accessions were screened for disease resistance. The screening rests indicated that two different strains of cowpea mosaic virus were present in the two locations. Of the 104 cultivars tested 13 were resistant to the CPMV strain in Puerto Rico. Also, seven of the accessions were free from bacterial blight and canker.

4. Shipment of Seeds of Released Varieties to Cooperators and Interested Researchers During 1974.

Seeds were sent to 25 foreign countries and to 9 states of the United States and others in Puerto Rico. In the foreign countries 29 researchers received 19 sets of P. vulgaris and 20 sets of V. unguiculata multiple disease resistant lines. In the United States 13 researchers received 13 sets of P. vulgaris and 5 sets of V. unguiculata multiple disease resistant lines. In Puerto Rico 6 researchers received 5 P. vulgaris and 4 V. unguiculata multiple disease resistant lines.

5. Release of Germ Plasm.

Notice to plant breeders of the release of three dry bean hybrids with multiple disease resistance characteristics, USDA/ARS, January 4, 1974.

Notice to plant breeders of the release of fourteen selected rust resistant bean lines, USDA/ARS, March 11, 1974.

8. Project Design and Methods.

There are four major activities, all of which contribute to the realization of the research objective of controlling diseases and insects of beans, cowpeas, and other food legume crops in the tropics.

a. Virology studies

This activity will phase out in FY-76 with the incorporation of an ultramicrotome facility into the electron microscope work, and the refinement of the "air brush" technique for inoculating plants with a specific virus. Both of these techniques will facilitate the determination of resistance in the plant breeding phase.

b. Control of Fungus and Bacterial Diseases

A number of commercial fungicides and bactericides have already been tested for controlling the common diseases of legumes in the tropics. Further tests on the application time and rate will be made, and new experimental fungicides will be included in the evaluations. Also to be included will be any new strains of diseases which are divulged. Determinations to be made of varieties which demonstrate consistent resistance to diseases.

c. Entomology

This activity will parallel item b., above, as it relates to insect attacks and insecticides. An added element will be the study of natural

enemies of the major insects which attack legumes. The scientists will endeavor to identify varieties which are most resistant to insect attacks.

d. Plant Breeding

Varieties or lines of legumes which possess good cultural characteristics will continue to be crossed with those types identified for their disease and insect resistance (items b. and c., above) in the hopes of combining all of the desirable traits into a few varieties which would then be tested on a worldwide basis.

Graduate students will be trained in the various functions involved in this research program. Inputs for each activity are included in the Work Plan below.

9. Work Plan.

a. Virology: This subsection will be completed with the end of FY 1976. This year's activities will include further characterization by electron microscopy and the use of an ultramicrotome attachment to make ultrafine sections of plant tissue to determine the existence and type of virus active in the plants.

An electron microscopist will be recruited for six months to train UPR staff in the expert use of the electron microscope and its accessories. Five research assistants are expected to be trained.

Dr. Karl Maramorosh will serve as consultant in the evaluation of the Virology Section Research.

The project developed "air brush" technique of inoculating plants with a specific virus for positive infection to determine positive resistance will be further refined and UPR and MITA staff trained in its use.

Two publications are planned for the year, one on the mechanical inoculation with the golden yellow mosaic virus and one on Euphorbia virus as related to beans.

Current project staff and equipment either on hand or being made available will meet subsection research needs. To train staff in electron microscopy a Spanish speaking expert from Brazil has been located and is available for a six-month's training program.

Six professional staff and three technical staff providing 43 m/m with 30 m/m of labor will provide a total of 73 man/months of efforts during this funding period. Costs for the total budget are $78,000.

b. Control of Fungus and Bacterial Diseases: Trials will be expanded to control diseases of legumes other than beans and cowpea. Of particular interest is pigeon pea (Cajanus, cajan) and canker diseases caused by the fungi Phana Cajan, Phylerphthard parasitica, and Balryodypladia.

(1) Work Plan 1976-77.

(a) Common Bacterial Blight of Beans.

Trials will be conducted in the field, both at the Isabela and Lajas Substations in order to establish how effective are the fungicides

(bactericides) Copper 53 and Kocide 101 in controlling common bacterial blight. A new fungicide (Bactericide), Nabac 25, will also be tested against the disease. In vitro tests in the laboratory will also be conducted in which this bacterial pathogen will be exposed to each of the three above-mentioned chemicals as well as to any other newly developed bactericide on hand.

(b) Rust of Beans.

Two experiments will be established, one at the Isabela and the other at the Lajas Substation in which Plantvax and Dithane M-45 will be tested against bean rust. A third fungicide, Triforine, will also be tested. Experimental designs and methodology will be essentially the same as those employed for previous trials.

(c) Powdery Mildew of Cowpea.

In spite of the perfect control displayed by Benlate on powdery mildew for the first two field experiments conducted to screen various fungicides against this disease, it failed to effectively protect the foliage of cowpea during a third trial. Therefore, an additional trial must be conducted in order to establish if failure of this fungicide to protect against powdery mildew is due to inactivation of the chemical by adverse storage conditions or due to the development of new physiologic races of the fungus resistant to the chemical. The trial will be established at the Isabela Substation. The experiments for the detection of races resistant to Benlate will be conducted in the greenhouse.

(d) In Vitro Screening of Chemicals

Laboratory tests are underway in which both EL 370 and Benlate are tested against the fungus Corynespora cassiicola. Other fungicides and bactericides to be tested are Nabac 25, Kocide 101 and Daconil either on C. cassiicola or

on Cercospora spp. and Xanthomonas phaseoli. Both dry weights and radial growth of these microbial pathogens will be recorded for each chemical under study.

(e) Physiologic Races of Bean Rust

Bean leaves infected by U. appendiculatus will be collected from all the bean growing areas of the Island as well as from experimental plots established at the Substations. This material will be in turn purified in the greenhouse by employing cultivars which are highly susceptible to the disease. At least 20 bean differentials of those obtained from United States, Brazil, Colombia and Australia will be exposed to the material collected throughout the Island.

(2) Work Plan 1977-78.

(a) Complete the work initiated in 1975-76 and 1976-77 on chemical control of those diseases which are endemic on both beans and cowpeas.

(b) Find means of control for those diseases reported as new to beans and cowpea in Puerto Rico

(c) Test newly developed pesticides (fungicides and bactericides) against endemic as well as against new diseases of both beans and cowpea in the laboratory, greenhouse and under field conditions.

(d) Initiate research directed to control diseases of legumes other than cowpea and beans, such as pigeon peas and chickpeas. An important disease of pigeon peas in Puerto Rico is stem canker caused by the fungus Phytophthora parasitica.

(3) Work Plan 1978-79.

Continue research directed to control diseases of edible legumes, with special emphasis on those which represent a menace to the economic production

of these legumes under cultivation.

To continue testing fungicide and bactericide as they are released by the chemical companies.

Eight professional staff and three technical staff plus 12 m/m of labor provide a total of 54 m/m for FY 76 and 95 m/m in FY 77 & 78. Total budget costs are $70,000 in 1976, 114,000 in 1977 and $122,000 in 1978.

Major equipment to be purchased in FY 76 includes, a growth chamber, transfer chamber, incubator, two dissecting scopes and a hygrothermograph. No further equipment needs are foreseen through the project life.

(4) Expected Products and Time Frame for Accomplishment.

(a) Information in 1977 on the control of bacterial blight of bean caused by Xantomanas phaseoli via the fungicides and/or bactericides, basic copper sulphate, copper hydroxide, and Nabac 25.

(b) Information in 1977 on the control of rust of beans, caused by Uromyces appendiculatus, via the fungicide manzoceb, oxathiin (Plant Vax) and the systemic compound Triforine.

(c) In 1977, an explanation of why the systemic fungicide benomyl, which had provided excellent control of powdery mildew of cowpea, did not control the disease in the last test conducted at the Isabela Substation.

(d) An in vitro evaluation of compounds for control of the target spot (cowpea) and bacterial blight (beans) causal organisms (1978).

(e) Indications in 1978 on the races of the bean rust pathogen present in Puerto Rico.

(f) A screening of cowpea accessions for resistance stem canker-inciting pathogens (1978).

c. Work Plan - Entomology - 1976-78.

(a) Continue field tests for the screening of new selections and/or varieties of beans and cowpeas to determine the presence of resistance to the major insect pests, particularly, to the leafhopper , Empoasca fabae, to the leaf-miner, Liriomyza sativae and to the dry seed weevil, Acanthoscelides obtectus on beans, to the bean beetle , Cerotoma ruficornis on beans and cowpea and to the cowpea weevil, Chapcodermus ebeninus, and to the dry seed weevil , Callosobruchus chinensis on cowpea. This screening should continue for at least 1976-77 and 77-78.

(b) Conduct field test to evaluate insect attack and damage on selected varieties of beans and cowpea. Efforts will be made to determine the effect of different levels of insect populations on yield. This will be started this year for the leafhopper on two varieties of beans, one susceptible and one resistant. Similar tests will be conducted during the following three years in order to determine the insect population causing economic damage.

(c) Field test will be initiated with existing commercial varieties of pigeon-peas to evaluate insect damage, particularly of pod-borers (Heliothis spp.) at different planting time through the pigeon pea season. For this, eggs of Heliothis will be counted at pod setting in all planting through the season to determine the insect damage at different levels of egg infestation. This should be done for at least three years in order to obtain reliable data to predict insect damage based on egg counting at pod setting which is the time to decide on control measures.

Based on the above results insecticide trials could be done (probably after 3 years of data) for the refinement of control measure decision (timing).

Efforts will be made to determine the natural enemy complex of Heliothis

larvae in Puerto Rico, and eventually, its efficiency on control. The effect of recommended insecticides on natural enemies will, also, be studied.

(d) Continue field plot, shade house and laboratory studies to provide information on the natural enemy complex of the leafminer, Liriomyza sativae. These studies should continue for at least 3 years. Once the potential enemies are identified, the efficiency of these should be determined as well as the adverse effect of recommended insecticides.

(e) Continue field test to evaluate chemicals for control of insect pests on the above crops, particularly for the leafhoppers, leafminers, the bean beetle, the cowpea weevil and the dry seed weevil. Emphasis will be given to secure minimum chemical dosages that will control the above mentioned insects.

A staff of three professionals and one technician will be required through the life of the project. They will provide 55 man/months including field and laboratory labor staff in FY 76 and 94 m/m each in FY 77 and 78. A portable area meter and a stereomiscroscope fitted with photography equipment will be major equipment needs in 1976. No other major equipment needs are foreseen. Annual funding requirements are $39,000 in FY 76 and $58,000 in FY 77 and $63,000 in FY 78.

d. Plant Breeding for Resistance.

This portion of the work plan will be presented under the individual species being investigated or to be included in the near future.

(1) Common bean (Phaseolus vulgaris).

(a) Exchange of advanced lines with other bean improvement programs (1976-77).

(b) Incorporate major sources of multiple resistance into one or more populations of manageable size. (1976-77)

(c) Test these populations for reselection of higher accumulated resistances and for favorable agronomic characteristics. (1977-78)

(d) Initiate tests to preserve the highest level of nutritive values with the reselection for high multiple disease resistant types. (1977-78)

(e) Release advanced high yielding disease resistant lines. (1977-78)

(f) Determine the genetic base and inheritance of resistance to some of the diseases tested. (1977-78)

(2) Cowpeas and Yardlong (Vigna unguiculata and sesquepedalis).

(a) Continue crossing and reselection for the accumulation of multiple disease resistance. (1976-77)

(b) Initiate breeding program for the incorporation of yield and quality characteristics of adaptable commercial types into the multiple disease resistant material. (1976-77-78)

(c) Develop cooperative testing of advanced disease resistant lines for adaptability and yield with other tropical countries. (1976-77)

(d) Release improved high yielding disease resistant cowpeas and yard long beans. (1977-78)

(e) Incorporate male sterility into breeding lines and populations. (1977-78)

(3) Tepary Bean (Phaseolus acutifolius.

(a) Obtain germ plasm from areas where the tepary is native or in cultivation. (1976-77)

(b) Evaluate for disease resistance, yield and adaptability under tropical conditions. (1977-78)

(c) Cross and select for multiple disease resistance. (1977-78)

(4) Scarlet Runner Bean (Phaseolus coccineus).

(a) Increase germ plasm base through acquisitions and collections. (1976-77)

(b) Screen for multiple disease resistance through the formation of separate bush and vine type composites or populations. (1976-77)

(c) Develop multiple disease resistant types for transfer to P. vulgaris. (1976-77)

(d) Isolate important agronomic and morphological characteristics into compatible lines from which they can be transferred to P. vulgaris. (1976-77)

(e) Develop commercial types for adaptability and yield testing. (1977-78)

(5) Lima Bean (Phaseolus lunatus).

(a) Increase germ plasm base through acquisitions. (1976-77)

(b) Continue screening for multiple disease resistance to reduce the number of lines to a more manageable quantity. (1976-77)

(c) Test advanced lines for their range of adaptability and yield (1977-78)

(6) Pigeon Pea (Cajanus cajan).

(a) Cooperate with the University of Puerto Rico on the important international disease problems. (1976-77-78)

Priority and Time Distribution for Principal Research Personnel

Crop	Priority 10=high	Pathologist % of Time	Breeder % of Time
P. vulgaris	10	30	50
V. unguiculata	9	30	20
V. unguiculata sesquipedalis	6	10	10
P. acutifolius	3	10	10
P. coccineus	3	10	10
P. lunatus	3	10	--
C. cajan	2	--	--

Nine professional and four technical staff will be assigned to the project. Counting assigned laborers a total of 195 m/m will be used in FY 76 and 334 each in FY 77 & 78. Projected funding requirements are $139,000 in FY 1976, $223,000 in 1977 and $237,000 in 1978. Special equipment needs will consist of field cultivators, a portable bean plot thresher, microscopes and sprayers.

10. Environmental Impact.

The overall aim of this research project is to increase the food availability to the people of the LDCs. It hopes to accomplish this by reducing losses presently caused by diseases and insects. Ideally, biological control methods will be identified, - barring this, various chemical controls will be indicated. In either case, the effects of other biological forms or of chemicals will be taken into account before any recommendations are made, so that any possible adverse environmental effects will be duly considered.

Further grain legumes properly inoculated fix nitrogen from the air to essentially meet plant requirements. A residual is left on root nodules to reduce the nitrogen requirement for future crops. This results in a lowered requirement for chemical nitrogen, saves fossil based fuels and reduces soil and water pollution. The benefits to be derived from this work are not biased toward any particular economic or social segment of the population of LDCs.

10. General Appraisal.

The 1974 PAR indicated progress was as planned and no major production or administrative problems had arisen. Transitional problem of transferring the project to UPR leadership had essentially been solved. Some divergence and lack of communication still existed and more staff meeting and improved exchange of information on each team member's activities was recommended.

Broadening the scope of the project to include other grain legumes was also recommended. As facilities, time and staff permit this is being accomplished.

As part of the outreach effort, including more LDC graduate students as research assistants on the project was suggested.

In the 1975 project review progress was noted in all of the 1974 recommendations. Some work is now being done or planned on pigeon pea, yard long bean and lima beans. Three graduate students have been assigned to the project and improved communication was evident.

The 1975 review again noted good progress on research objective. Virology studies have progressed to the point that they can be terminated at the end of FY 1976. With more proven results being available increased outreach and training activities can be started. Also closer coordination with the soybean project and exchanges of pertinent information was suggested.

In summary, reviews indicate a successful project on schedule with objectives being met.

PROPOSING OFFICE GENERAL EVALUATION AND RECOMMENDATION

The project continues to hold the highest priority among the projects supervised by the Office of Agriculture and is an integral part of the program of the Division of Crop Production. It addresses directly, by improvement of the grain itself, the all important problems of hunger and malnutrition as well as making a contribution towards the improvement of the lot of the small farmer.

A three year extension will allow for the realization of important research in progress and solution of problems directly affecting food production and nutrition in the LDCs.

Leon F. Hesser, Director
Office of Agriculture, TAB

Milestone Life of Project Schedule

Objective/Product	Extension of Project Start FY 1976	FY 1977	Project Completion FY 1978
A. Virology Studies	(S)----------(C)		
1. New virus characterization	(S)----------(C)		
2. Ultra _____ activity	(S)----------(C)		
3. Electron microscope training	(S)---------(C)		
4. Training in manual "air brush" virus inoculation	(S)---------(C)		
5. Data Publication Activity	(S)----------(C)		
B. Fungi & Bacteria Diseases	(S)----------	----------	----------(C)
Powdery Mildew Studies	(S)----------	----------	----------(C)
Leaf Blight Studies	(S)----------	----------	----------(C)
Leaf spot studies	(S)----------	----------	----------(C)
Rust studies	(S)----------	----------	----------(C)
Natural means of control		(S)----------	----------(C)
New disease studies		(S)----------	----------(C)
Other Grain Legume Studies		(S)----------	----------(C)
C. Entomology	(S)----------	----------	----------(C)
1. Bean and cowpea screening for major insect resistance.	(S)----------	----------	----------(C)
2. Determine economic level of insect populations.	(S)----------	----------	----------(C)
3. Pigeon pea screening for insect resistance levels.	(S)----------	----------	----------(C)
Egg count and natural enemies will be studied.			

Milestone Life of Project Schedule (Cont'd)

Objective/Product	Extension of Project Start FY 1976	FY 1977	Project Completion FY 1978
C. 4. Evaluate chemical control of major insects	(S)----------	----------	----------(C)
D. Plant Breeding			
Common Bean			
1. Exchange bean lines with other improvement programs and incorporate multiple resistance in one or more populations	(S)----------	----------(C)	
2. Select for favorable agronomic characteristics and high nutritive values in multiple disease resistant bean types.		(S)----------	----------(C)
3. Release most promising lines		(S)----------	----------
Cowpea & Yard Long			
4. Develop multi-resistance and commercial quality	(S)----------	----------	----------(C)
5. Develop cooperative breeding programs and release promising new lines		(S)----------	----------(C)
Tepary Bean			
6. Increase germ plasm bank and disease resistance and quality characteristics	(S)----------	----------	----------(C)
7. Cross and select for multi disease resistance		(S)----------	----------(C)
8. Increase germ plasm base and screen for multi disease resistance and commercial quality traits.	(S)----------	----------	----------(C)

Milestone Life of Project Schedule (Cont'd)

Objective/Product	Extension of Project Start FY 1976	FY 1977	Project Completion FY 1978
9. Develop resistance and agronomic traits in lines compatible for transfer to common bean (P. vulgaris) Lima Bean		(S)----------(C)	
10. Increase germ plasm, screen for desired traits, test advanced lines for range of adaptability and yield. Pigeon Pea	(S)----------	----------	----------(C)
11. Screen available material and cooperate closely with UPR staff in developing commercially acceptable varieties	(S)----------	----------	----------(C)

FORMAT FOR WORKPLAN/CONTRACT BUDGET AND LIFE-OF-PROJECT COST ESTIMATE

INPUTS	76** Man Mos.	76** Est'd Cost (000) $	77 Man Mos.	77 Est'd Cost (000) $	Prior Years Costs (000) FY 73-74-75 $	To Project Completion (000) FY 1978 $	With FY 73 & 74 75 Cost Total Est'd Life of Proj. Research Cost (000) $
	First Two Fiscal Years						
1. Salaries	378	166	523	220	444	230	1060
2. Consultants	.2	1		0	0	0	1
3. Fringe Benefits	378	19	523	25	48	26	118
4. Overhead	378	93	523	124	234	130	590
5. Travel and Trans.		20		17	24	17	78
6. Allowance							
7. Other Direct Costs							
8. a. equipment, vehicles		32			28		60
b. materials and supplies		9		9	13	9	40
9. Publications							
Total Costs by Inputs	378	340	523	395	800	422	1957
OUTPUTS*							
Research Object. #1 (Virology)	73	92	-	-	184	-	276
Research Object #2 (Bacteria & Fungus)	54	70	95	114	201	122	507
Research Object #3 (Entomology)	56	39	94	58	109	63	269
Breeding (MITA) #4	195	139	334	223	306	237	905
Total Costs by Outputs	378	340	523	395	800	422	1957

*Research objectives or other program categories as described in Items 8 of project statement.

**Seven months funding only. FY 77 & 78 full 12-month funding.

AID 590-28(11-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Life of Project:
From FY ____ to FY ____
Total U.S. Funding ____
Date Prepared: ____

Project Title & Number: Imp Trop Prod Beans and Cowpeas

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: To increase quantity and nutritional value of food crops in developing countries.	Measures of Goal Achievement: 1. Significant increase in per capita production of major food crops in LDC's. 2. Improvement in nutritional quality of major LDC food crops with emphasis on protein levels.	1. LDC crops production records. 2. International agency and FAS crop estimates. 3. Nutritional quality surveys in LDC's.	Assumptions for achieving goal targets: 1. LDC's will devise policies to encourage improve food production. 2. Varieties available that improve nutritional quality without reducing yields.
Project Purpose: Improve the tropical production of beans and cowpeas through disease and insect control.	Conditions that will indicate purpose has been achieved: End of project status. 1. Multidisease-resistant varieties available to LDCs. 2. Research and development responsibility assumed by LDCs and international institutes. 3. Nucleus of expert staff and research facilities developed at UPR and key Latin American countries. 4. Technical reference material published and disseminated.	1. Disease-resistant germplasm identified. 2. Disease-resistant material under trial in LDCs. 3. LDC personnel in training. 4. Materials and information exchange with LDCs and International Institutes. Conducting of Seminars. 5. Seminars and workshop proceedings published and distributed.	Assumptions for achieving purpose: 1. Problems of yield and nutritional quality with resistance can be solved. 2. LDC training and extension staff can train farmers in new technology. 3. LDC's research institution can perform required functions.
Outputs: 1. Search for disease-resistant genotypes of beans and cowpeas. 2. Development of multidisease-resistant lines. 3. Training of LDC personnel. 4. Establishment of exchange linkages. 5. Bank of research findings.	Magnitude of Outputs: 1. 13 lines of disease resistant cowpeas released. 2. 19 lines of disease resistant beans released. 3. In 1974 3 dry bean hybrids with multiple disease resistance released. 4. In 1974 14 rust resistant bean lines released.	1. USDA (NPGA) and UPR records. 2. Breeding records of national and international cooperating research institutions.	Assumptions for achieving outputs: 1. LDC's and USAID's will request and use research findings and technical assistance available. 2. Cooperation of International Institutions. 3. Available staff and resource in LDC's.
Inputs: 1. Qualified personnel, campus and field facilities provided by contractor. 2. Budget support provided by AID/W. 3. Personnel, facilities and local support provided by LDCs. 4. International linkages and development strategy assisted by CIAT.	Implementation Target (Type and Quantity) 1. 400 mm per year provided by contractor. 2. $400,000 budget provided by AID/W. 3. Adequate research field and laboratory facilities to use inputs. 4. Linkages established with CIAT, IITA, and ICRISAT.	1. AID/W records. 2. Contract reports on site inspections. 3. USAID reports, on site inspections. 4. International and national program records.	Assumptions for providing inputs: 1. AID/W funding will be available. 2. Contractor staff and facilities will be adequate. 3. International institutions, LDC's and USAID's will have personnel and resources to support this activity.

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November 18, 1975

MEMORANDUM FOR: Members of the Research and Development Committee

FROM: TA/PPU, Carl R. Fritz

SUBJECT: Research & Development Committee Meeting -- November 25, 1975

A meeting will be held at 2:00 p.m., Tuesday November 25, 1975, in Room 2884, NS. The following following Project Statement will be presented for review by the Committee:

Improvement of Tropical Production of Beans and Cowpeas Through Disease and Insect Control. University of Puerto Rico, Research, KPA #2.

Attachment: a/s

Distribution:

(See attached sheet)

DISTRIBUTION FOR RESEARCH AND DEVELOPMENT COMMITTEE MEETINGS (R & DC)

RESEARCH AND DEVELOPMENT COMMITTEE

A. MEMBERS

AFR/DP, Frank Moore

EA/TD, Herbert Dodge
LA/DR, Charles Stockman
NESA/TECH, James Dalton
GC/TF&HA, A. R. Richstein
SER/IT, Joseph Kovach
SER/ENGR, John Rixse
SER/CM/COD, Robert J. O'Brien
FFP/FDD, P. Sheehan
PPC/DPRE, Arthur Handly
PHA/POP, Steven Sinding
O/LAB, Sigurd Moody

B. ALTERNATES

AFR/DS, John Blumgart w/att.
AFR/NARA, Woodrow Leake w/att.
EA/TD, Fletcher Riggs w/o att.
LA/DP, Austin Heyman w/att.
NESA/DP, Richard Birnberg w/att
GC/TF&HA, Jan Miller w/o att.
SER/IT, Dale Clark

SER/CM/COD, V. Perelli w/o att.

PPC/DPRE, Norman Cohen w/o att
PHA/PVC, Cleo Shook w/att.
OLAB, Paul Fera

C. INFO

A/AID, H. Kosters w/o att.*
IGA, John Kurelich w/att.
PPC/RB, L. Rogers w/att.
SER/MP, N. Ayers w/o att*
PPC/PDA, R. Muscat w/o att.

A/AID, Gilda Varrati w/att.
OMB, Ed. Sanders, w/att.

D. TA OFFICES

AA/TA, C. Farrar
M. Belcher
E. Long
K. Levick w/o att.*
T. Arndt
S. Butterfield
M. Kilgour
T. Brown
TA/PPU, C. Fritz
J. Gunning
T. Eliot (211(d))
C. Molfetto
TA/PPU/EUI, D. Myren
TA/AGR, L. Hesser
TA/DA, J. French
TA/EHR, J. Chandler
TA/H, L. Howard
TA/N, M. Forman
TA/OST, H. Arnold
TA/RES, M. Rechcigl
TA/TS, W. Jones
TA/UD, W. Miner
TA/RD, T. Owens
TA/PPU Analysts (as appropriate)

TA/MGT, L. Crain
TA/PPU, E. Shields, R & DC Files

(*Attachments on request)
Rev. 10/75

FORMAT FOR WORKPLAN/CONTRACT BUDGET AND LIFE-OF-PROJECT COST ESTIMATE

INPUTS	76** Man Mos.	76** Est'd Cost (000) $	77 Man Mos.	77 Est'd Cost (000) $	Prior Years Costs (000) FY 73-74-75 $	To Project Completion (000) FY 1978 $	With FY 73 & 74 & 75 Cost Total Est'd Life of Proj. Research Cost (000) $
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Breeding (MITA) #4	195	139	334	223	306	237	905
Total Costs by Outputs	378	340	523	395	800	422	1957

*Research objectives or other program categories as described in Items 8 of project statement.

**Seven months funding only. FY 77 & 78 full 12-month funding.

AID 320-28(11-72)

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

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From FY _____ to FY _____
Total U. S. Funding _____
Date Prepared: _____

Project Title & Number: Imp Trop Prod Beans and Cowpeas

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Project Purpose: To investigate the nature, distribution, and control of diseases and related insects of grain legumes limiting production in the tropics.	Conditions that will indicate purpose has been achieved: End of project status. 1. Multidisease-resistant varieties available to LDCs. 2. Research and development responsibility assumed by LDCs and international institutes. 3. Nucleus of expert staff and research facilities developed at UPR and key Latin American countries. 4. Technical reference material published and disseminated.	1. Disease-resistant germplasm identified. 2. Disease-resistant material under trial in LDCs. 3. LDC personnel in training. 4. Materials and information exchange with LDCs and International Institutes Conducting of Seminars. 5. Seminars and workshop proceedings published and distributed.	Assumptions for achieving purpose: 1. Problems of yield and nutritional quality with resistance can be solved. 2. LDC training and extension staff can train farmers in new technology. 3. LDC's research institution can perform required functions.
Outputs: 1. Search for disease-resistant genotypes of beans and cowpeas. 2. Development of multidisease-resistant lines. 3. Training of LDC personnel. 4. Establishment of exchange linkages. 5. Bank of research findings.	Magnitude of Outputs: 1. 13 lines of disease resistant cowpeas released. 2. 19 lines of disease resistant beans released. 3. In 1974 3 dry bean hybrids with multiple disease resistance released. 4. In 1974 14 rust resistant bean lines released.	1. USDA (MITA) and UPR records. 2. Breeding records of national and international cooperating research institutions.	Assumptions for achieving outputs: 1. LDC's and USAID's will request and use research findings and technical assistance available. 2. Cooperation of International Institutions. 3. Available staff and resources in LDC's.
Inputs: 1. Qualified personnel, campus and field facilities provided by contractor. 2. Budget support provided by AID/W. 3. Personnel, facilities and local support provided by LDCs. 4. International linkages and development strategy assisted by CIAT.	Implementation Target (Type and Quantity) 1. 400 mm per year provided by contractor. 2. $400,000 budget provided by AID/W. 3. Adequate research field and laboratory facilities to use inputs 4. Linkages established with CIAT, IITA, and ICRISAT.	1. AID/W records. 2. Contract reports on site inspections. 3. USAID reports, on site inspections. 4. International and national program records.	Assumptions for providing inputs: 1. AID/W funding will be available. 2. Contractor staff and facilities will be adequate. 3. International institutions, LDC's and USAID's will have personnel and resources to support this activity.

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PROJECT STATEMENT

AID/University of Puerto Rico Contract,

"Improvement of Tropical Production of Beans and Cowpeas Through Disease and Insect Control".

Purpose

No. AID/CM/ta-C-73-26

October 1975

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PROJECT STATEMENT

A. PROJECT SUMMARY

1. Statistical

Project Title: Improvement of Tropical Production of Beans and Cowpeas Through Disease and Insect Control

New or Extension: Extension

Contractors: College of Agriculture, the University of Puerto Rico (UPR), Mayaguez, Puerto Rico. Mayaguez Institute of Tropical Agriculture, U.S. Department of Agriculture, Cooperating.

Principal Investigators: Dr. J. H. Lopez-Rosa, Plant Pathologist; Dr. Carlos Cruz, Entomologist; Dr. Pedro Mellindez, Plant Pathologist - Dr. Julio Bird, Bean Pathologist - University of Puerto Rico; Dr. N. G. Vakili, Pathologist, Plant Breeder, Dr. G. F. Freytag, Plant Breeder - U.S. Department of Agriculture

Duration: April 1, 1976 - October 31, 1978

Total Estimated Cost: $1,957,000

Funding:

Prior Years funding - 1973 to 3/31/76	$800,000
Project Extension Funding - 4/1/76 - 10/31/76	340,000
FY 1977	395,000
FY 1978	422,000

Project Manager: Keith Byergo

Narrative:

During the initial two years of this project, the University of Puerto Rico (UPR) staff in conjunction with the USDA Mayaguez Institute of Tropical Agriculture (MITA) staff have established a sound base for research in tropical bean and cowpea culture. With competent staff and facilities, they are in a position over the next 2½ years to provide varieties of beans and cowpeas that have commercially accepted quality, and due to inbred multi-resistance to prevalent insects and diseases of Latin America, greatly increased yields. Already released varieties are being commercially produced and are in general use in the national and international grain legume development programs of the region. by whom?

As detailed in the initial project statement, legumes are the principal protein source of the target area, the LDCs in Central and South America and the Caribbean. Further, developments in Puerto Rico are often applica and useful in Asian and African Grain legume work.

Research is in progress in the areas that follows: (1) surveys for and studies to properly characterize virus diseases and develop simplified methodologies to enable the evaluation of germ plasm for resistance to the etiological agents of the diseases in Tropical America, (2) evaluation of chemicals for the control of disease agents and insects, (3) surveys of nematodes, (4) evaluation of germ plasm for resistance to diseases and insects, and (5) breeding work to produce high yielding lines and cultivars with multiple resistance to diseases.

Work on the above mentioned aspects is conducted at the Agricultural Experimental Station of the University of Puerto Rico, Mayaguez Campus, at facilities located in Rio Piedras and Mayaguez and in various substations; in MITA at Mayaguez and regional substations; and cooperatively in various Central American countries; at CIAT, Cali, Colombia and the University of Wisconsin.

As an institution building exercise, the current internationally recognized competence of the University of Puerto Rico in the field of grain legumes vouches for the success of the project in this area. Newly released varieties, consultancies, graduate students, seminars and published papers, the Workshop on Tropical Disease of Grain Legumes and the resulting book, all have attested to the excellent capability of the project institutions and their staff.

2. Research Purpose and Expected Products:

Purpose:

The major objective of this project is to study the insect and disease problems effecting production of grain legumes in the tropics and to develop and disseminate means of control. Also of high priority is improving grain legume research and production competence in LDCs.

Expected Products:

1. Multiresistant varieties of beans and cowpeas for commercial production, suited to the various ecological conditions in tropical and subtropical areas will be the principal product of this research.

2. A germ plasm bank of a size and variety to constitute a major source of breeding material for cooperating national and international programs.

3. An experienced and well equipped staff at UPR with internationally recognized competence in grain legume insect and disease control and a bank of knowledge available to other institutions involved in like work. This will constitute a resource to continue the research necessary to maintain viable lines of grain legumes against the evolution of new diseases and insects. It is foreseen that the current grain legume programs of CIAT, IITA, ICRISAT and major national programs will benefit sufficiently from the work initiated under the AID/UPR contract to continue the necessary research and development following completion of the contract.

4. A staff of newly trained scientist who will constitute a nucleus of expertise in developing competent national programs in grain legume production.

5. A system of linkages between institutions involved in grain legume research that will assure continuing cooperative efforts in the exchange of research and production technology.

3. Significance and Rationale for the Research:

A key project area of AID assistance has been the improvement of basic food crops with emphasis on high quality and higher level assimilable protein. Research activities currently are supported for the development of improved protein in wheat, maize and sorghum. AID recognizes that inherently grain legumes are a better source of plant protein for human consumption than the

new cereals. They contain 20 to 40 percent protein compared to the cereal grains which average only ¼ to ½ this amount. Although there exists a great potential for increasing present day yields of these crops, until the initiation of this project little research has been done on tropical grain legumes as compared to that in the cereal crops. Commercial planting of newly developed project bean varieties have produced 2 tons per acre in Puerto Rico. This compares with average yields of 500 to 600 pounds per acre.

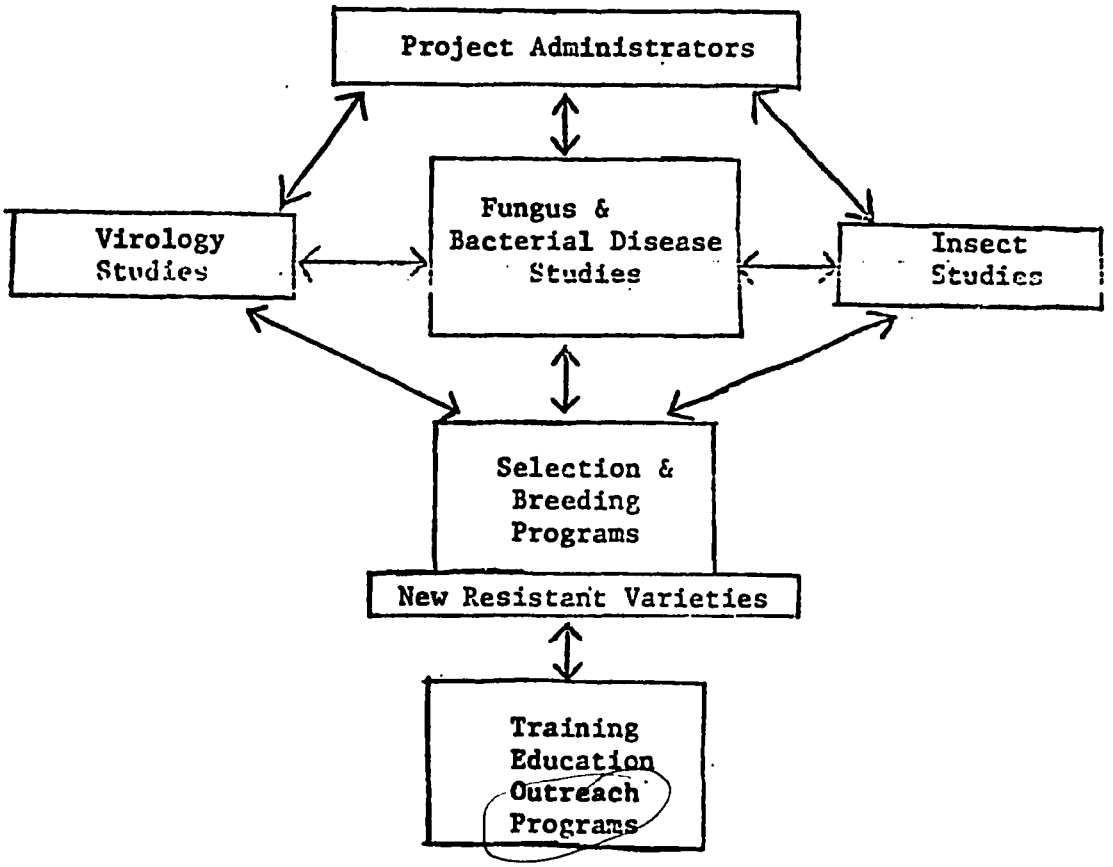
In much of Latin America, Africa and Asia grain legumes are the second largest food crop both in areas and tons of production, and the primary protein source. Population increases in LDCs also increase aggregate demand for grain legumes. More efficient production, other things being equal, mean a higher return to the small farm producer. For this reason, AID considers research in the beans and cowpeas to be of very high priority.

AID through it's initiative can make a significant contribution in the basic research and training necessary for national programs to develop. The first two years of the project have defined the problem and indicated answers. This proposed 2½ year extension would develop the bank of knowledge and technical expertise from which national and regional programs could build.

This two-year involvement of the University of Puerto Rico in cooperation with USDA has been a productive period with advances being made on all fronts to increase grain legume yields particularly beans and cowpeas.

Building on staff, facilities and technical information that has been developed over this period, it is reasonable to assume that commercially acceptable varieties of higher yield and protein quality potential will evolve from research conducted during a 2½ -year extension of the contract.

Schematically the project functions as follows:



4. Plans to Coordinate and Link Research:

The extension of the bean and cowpea project shall constitute an AID contribution to the worldwide legume development program. It will be closely integrated with research on the grain legumes carried out at the international research institutes, as well as by regional and national research centers, and it is intended to complement their research programs. Much of the proposed work is of a more fundamental nature than that normally done at the international research institutes. In this way a major contribution will be made to existing adaptive and production type programs.

Following are the international institutions and grain legumes for which they have international network responsibility:

Crop	Responsible Institution
Pigeon peas	ICRISAT - India
Chickpeas	ICRISAT - India
Dry beans	CIAT - Colombia
Cowpeas	IITA - Nigeria
Mungbeans	AVRDC - Taiwan
Soybeans	USA - University of Illinois

It is with the institutions as well as with major national programs in Colombia, Honduras, Mexico and Costa Rica that the project staff maintain close linkages via seminars, workshops, consultations and research data and germ plasm exchanges. The workshop held at Mayaguez and one scheduled in Colombia, December 1st, 1975 on disease and insect control of grain legumes are examples of the close coordination fostered by project staff.

5. Plans to Facilitate Utilization of Research Results:

In addition to the above listed project linkages with other national and international programs, the publication of research findings and seminar and workshop proceeding, graduate students from LDCs in Central and South America have been assigned as research assistance to project staff. These students will form a nucleus in the home country for the dissemination of research information and establishing grain legume programs. how?

Within Puerto Rico the University extension specialist and village staff are kept informed of project findings and supplied with new germ plasm for adaptive research and demonstrations to local bean growers. As progress is made in the development of improved varieties greater effort will be made on outreach programs. The major contribution to date has been in research methodology and breeding programs.

6. Management Considerations:

Non-contract funded contributions comprise a sizeable input into the project. These consist of two USDA staff members, a plant pathologist and a plant breeder who work full time on the plant breeding aspects of the project. Also two members of the UPR staff make significant contributions to project research from their work on cultural practices and insect resistan Their studies are conducted on the more promising cultivars at the regional research stations of Isabela and Lajas.

Regular on site evaluations using non-project staff from USDA, regional bureaus or universities are planned. This has been the past policy and has been beneficial to the project as well as broadening the base of detailed information on the project.

Project leadership on site is provided by a UPR staff member. He is responsible for maintaining close coordination and communication between the MITA staff and UPR staff. With staff at Mayaguez, Rio Piedras and at regional stations this becomes a major and essential activity. Nonproject activities of the UPR are closely related and supportive of project research and must be incorporated and considered in analysis activities. The USAID project manager can be helpful in this coordination activity as well as assist in coordination with national and international centers.

7. Technical Review:

Yield comparisons of traditional varieties with newly developed disease and insect resistant varieties have shown a three-fold increase in yield where the nonresistant varieties are only partially infected with prevalent disease and insect pests. Heavy infection can result in no yield in non-resistant varieties. Having found resistant genes in certain cultivars, the problem now is to incorporate a number of resistant genes in stable commercially accepted varieties thus providing multiple resistance along with high quality and yield.

The original PASA with USDA made a start with research on grain legumes in India and Iran. The more difficult tropical environment is now being researched under the UPR/AID contract. In addition to international programs at IITA and CIAT, a number of Central and South American national programs are also being established.

The work in Puerto Rico is currently more extensive therefore work being done there in coordination with other national and international programs will be cited as an example of the current state of tropical grain legume research. This will be reported under five headings: Virus, Fungi and Bacteria, Entomology, Nematology, and Breeding.

A. Virus Diseases

The small group of virus workers in the project staff has been able to characterize, beside many other phytopathogenic viruses, 7 different whitefly-transmitted agents, determining their relative effect on important crops such as beans, cowpeas, and other valuable legumes. On this account Puerto Rico has become an important center for scientists endeavoring to solve problems relative to virus diseases of legumes (particularly rugaceous maladies). The methodologies developed by the group in connection with the establishment and maintenance of stock cultures of Bemisia tabaci and mechanical inoculation of bean plants with rugaceous (whitefly-transmitted) viruses have enabled scientists to adequately study similar disease agents of legumes in other parts of the tropical world. The fact that many of the rugaceous diseases have been properly characterized will make the job of identifying these (through the proper use of diagnostic plants and indicators) an easier task for others.

B. Fungus and Bacterial Diseases

The major research achievements during 1974 are as follows: foliar diseases of cowpea (cv Early Ramshorn) were effectively controlled by the fungicides benomyl, mancozeb, dinocap and chlorothalonil. Dosages of

benomyl as low as ¼ pound per acre applied biweekly were enough to prevent infection by Erysiphe polygoni, the causal agent of powdery mildew, and by the fungi Cercospora canescens and Corynespora cassiicola, causal agents of leaf spot and target spot, respectively. Yields as high as 1,925 pounds per acre were obtained when higher dosages of benomyl, chlorothalonil and mancozeb were employed. Dinocap was highly effective against powdery mildew during the dry season, but failed to protect the plants during rainy weather.

The systemic fungicides Plantvax and Triforine at the rates of 2 and ½ pounds per acre, respectively and mancozeb at the rate of 1 pound per acre protected the foliage of bean cultivars Blanca del Pafs and Bountiful against rust caused by Uromyces appendiculatus.

Both, Kocide 101 (copper hydroxide) and Copper 53 (tribasic copper sulfate) at the rate of 1 pound per acre were very effective in controlling common bacterial blight (Xanthomonas phaseoli) of bean cultivar R-19, as indicated by the low disease indexes evident on this cultivar when exposed to both fungicides. No significant differences in yields were detected among fungicide-treated and control plots due to the fact that bacterial invasion occurred after pods were already developed.

Exchange of information internationally, was accompanied by a "Tropical Diseases of Grain Legumes Workshop" held in Puerto Rico in June 1974. A book has recently been published covering the finding of the workshop edited by Dr. Julio Bird of the project staff and Dr. K. Maramorosch, Project Consultant.

C. Entomology

The most outstanding findings to date have been the identification of the most important insects attaching beans and cowpeas and the evidence of resistance or tolerance in some cultivars to the major insect pests. Evidence was found of resistance to the bean leafhopper, Empoasca fabae, and to the cowpea weevil, Chalcodermus ebeninus which are the most damaging insects of these crops in Puerto Rico and possibly in other tropical regions. Preliminary observations also suggest resistance in beans to the bean weevil, Acanthoscelides obtectus,

Other insects found on cowpeas were the vegetable leafminer, Liriomyza munda; pod borers, Maruca testularis and Eitella zinckenella; aphids and cutworms. Other insects observed on beans were the vegetable leafminer, Liriomyza munda; the bean beetle, Cerotoma ruficornis; (also on cowpeas) the sugar cane weevil, Diaprepes abbreviatus; the lesser cornstalk borer, Elasmopalpus lignosellus; the leaf roller, Urbanus proteus and other leaf tiers.

Besides the cowpea weevil and the leafhoppers, other insects of potential economic importance are the leaf miner, the bean beetles and the podborers. Populations of these insects should be observed carefully since an outbreak of any of them could reduce yields significantly.

Twenty-six lines of beans and cowpeas were field tested for the effectiveness of insecticides in controlling distinctive insects. Conclusive results will require further testing. Natural resistance and local predators are also being screened to reduce dependence on chemical control.

Evidence of resistance to leafhopper was found in eight selections of white beans. Colored beans however proved very susceptible. Resistance to cowpea weevil was also noted. All of these observations will require continued work and screening before varieties can be released for commercial production.

These findings will enable us to concentrate our research efforts to obtain resistance and to develop other measures to control the most important insects. Selected germ plasm shown to be resistant or tolerant to insects will be provided to the plant breeder.

D. Nematology

Work on the nematology phase has been limited to preliminary surveys. Nematodes representative of 12 genera of parasitic or suspected phytoparasites were found associated with beans and cowpeas at the Isabela Substation, and 7 genera with 28 cowpea accessions at the MITA farm, also at Isabela.

With the assignment in FY 76 of a nematode specialist from Canada on a year's sabbatical leave to MITA, it is expected that cultivars with resistance to known nematodes will be identified.

E. Breeding Program

The bean breeding has been dependent on the recuperation of natural field hybrids occurring from flower visitation by the carpenter bee (Xylocopa brasilianarum).

This technique of using carpenter bees to cross-pollinate normally self-pollinating beans has resulted in crossbred lines with rust and virus

resistance, day length insensitivity, better climatic adaptability and increased yield. Screening of the International Cowpea Disease Nursery has resulted in improved cowpea mosaic virus resistance.

Present emphasis is being placed on obtaining controlled manual crosses in the greenhouse for specific gene transfer and for the formation of an intercrossing population or gene pool of multiple disease resistant lines. Preliminary results indicate fairly high fertility (from 40-70% pod set) from the manual crossing, depending on the parents used. Of the 11 parents in use for the population formation, the red bean line 15R-148 has shown exceptional fertility both as a male and female parent. The use of a manual procedure for recombining resistant germ plasm now offers great promise for accelerating the bean improvement work.

The germ plasm collection has been increased with the addition of 566 new lines this year. This greatly broadens the base of parent stock for breeding programs and the selection of desirable plant characteristics. This will lead to cooperative testing with other regional institutions to increase yield, quality and resistance to insects and diseases prevalent in Latin America and the Caribbean.

Research Findings:

(1) Virulence Study of Xanthomonas Isolates.

A virulence study with Xanthomonas isolates indicated 14 Vigna unguiculata P.I. accessions were susceptible to Xanthomonas phaseoli (American

Type Culture Collection #9563), the causal organism of the common bacterial blight of beans. These inoculation studies suggested that: (a) culture #9563 was a mixture of X. phaseoli and X. vignicola, (b) it was contaminated with X. vignicola during increase, (c) X. phaseoli mutated to X. vignicola in passage through V. unguiculata accessions, and (d) it contains factors for virulence against certain V. unguiculata genotypes.

Inoculation test indicated that P. vulgaris gives primarily a leaf blight symptom while V. unguiculata produces stem canker symptoms. These two types of symptom development occurred irrespective of the Xanthomonas source.

Preliminary trials suggest that "Fuscans" type isolates lose their capacity for pigment development when passed through susceptible V. unguiculata accessions.

(2) Disease Resistance, Yield and Adaptability Trials with Beans

a. Resistance of locally grown cultivars

A number of final selections and trials were conducted on the adaptability, agronomic characteristics and disease resistance of bush beans for cultivation in Puerto Rico. This work was started in cooperation with Dr. Marcial Rico-Ballester, Horticulturist, Lajas Substation. Varieties Bonita, Galana, Colorada del Pais, and French Horticulture were recommended for cultivation in Puerto Rico. The extensive work on the selection of adaptable bush beans resulted in the selection of seven cultivars which were grown for replicated yield trials during 1975.

b. Red Bean Trials

From a total of 1,898 lines in 1970, the final screening of the red bean lines resulted in 28 selections in 1974. The screenings were done for both disease resistance and yield. These selections will be subjected to replicated yield trials.

The most widely resistant cultivars were Ecuador-299 and Mexico-235. Both cultivars are highly sensitive to daylength. Selection 15R-148 is a rust resistant, CBMV susceptible, field resistant to soil-borne diseases, daylength insensitive, moderate to high yielding, dark red Mexican, dry bean cultivar that could serve as an important cultivar for breeding red bean adaptable to tropical lowlands.

The most important diseases in descending order of their importance were Rhizoctonia root rot and stem canker, southern blight, ashy stem blight and CBMV.

Sensitivity to daylength and temperature, and resistance to diseases were some of the most important factors affecting the yields of beans under the lowland humid tropical conditions.

c. Black Bean Trials

Soil-borne pathogens caused severe loss of stand among the susceptible cultivars during the rainy summer season and were a limiting yield factor in beans.

Bacterial blight is a major foliage disease during the wet season. Due to absence of effective chemical control it was difficult to estimate the loss due to this disease.

Whitefly transmitted viruses (WFTV) caused severe loss in yield when infection occur prior to inflorescence. However, WFTV were not a limiting factor for yield, if attack occuured after pod set.

There was a distinct and significant difference in field susceptibility of bean cultivars to WFTV. Cultivar Venezuela 63 was disease-free while cultivar 51051 was 34.8% diseased. Also, golden yellow mosaic incidence was five times higher than Rhynchosia mosaic incidence.

The results of a black bean yield trial indicated that cultivars Mexico-309, 15R-55, 15R-42, Jamapa and 71-1R-113 had the highest yields among 12 tested. It was interesting to note that after 4 years of screening and breeding the advanced breeding lines developed in Puerto Rico (15R-55, 15R-42 and 71-1R-113) equaled the yields of the best advance line and commercial cultivar in Central America.

Bean cultivars varied in their level of susceptibility to web blight. Cultivar 15R-55 had the highest tolerance followed with Mexico-309. However, the latter cultivar, under field stress due to diseases and climate, has a tendency to develop flat seed.

Cultivar 15R-55 proved to be an outstanding candidate for release as adaptable, high yielding and disease resistant tropical black bean with an attractive seed form.

d. Bean Rust Resistant Trials

Field trial observations and data suggest that the following rust resistant cultivars La Vega, Jamapa, 15R-55, 15R-66, 71-1R-136-BK, and 15R-292 are good candidates for breeding adaptability, multiple disease resistance, and high yields in beans for the lowland tropics.

e. International Rust Resistant Tests

On April 13, 1973, a group of 22 rust resistant bean cultivars were sent to ten different countries for tests against endemic races. Up to date data from five countries have returned. The summary of these data shall be presented in the next annual report.

Some of the outstanding materials from these trials were:

- Cultivar PR-S-70-15R-42-1-BK was the only entry resistant to all endemic races in Southern Brazil.
- Cultivars PR-S-70-15R-55-BK, 15R-167-4-BK and PR-H-71-1R-113 were immune to rust races studied at Beltsville, Maryland.
- Cultivars PR-S-70-15R-87-BK, 15R-277, PR-H-71-1R-63 and 1R-69 were highly resistant to rust races in Colombia. Cultivar 15R-87-BK wa chosen as one of the parental lines in breeding high yielding disease resistant beans.
- In Australia, 12 of the 22 cultivars were resistant to all endemic rust races. Cultivar PR-S-70-15R-87-BK was used in a number of crosses. The analysis of data has indicated five factors for rust resistance. Cultivars PR-S-70-15R-210-BK and 15-R-66-1-BK were included in the rust nursery trials.
- In Costa Rica cultivars PR-S-70-15R-87-BK and 15R-277-BK were resistant to endemic races in five different locations.

3) Cowpea Disease Resistance Trials

a. Horticultural (Yardlong) Cultivars

Disease screening tests indicated that yardlong cultivars (Vigna unguiculata var. sesquipedalis) were highly susceptible to a wide range

of diseases. Selections were made for agronomic and horticultural characteristics and selected lines were tested in replicated trials. This work is continuing and the best agronomic types will be bred for disease resistance.

b. International Disease Nursery

In cooperation with International Institute of Tropical Agriculture, Ibadan, Nigeria, 104 cowpea accessions were screened for disease resistance. The screening rests indicated that two different strains of cowpea mosaic virus were present in the two locations. Of the 104 cultivars tested 13 were resistant to the CPMV strain in Puerto Rico. Also, seven of the accessions were free from bacterial blight and canker.

4. Shipment of Seeds of Released Varieties to Cooperators and Interested Researchers During 1974.

Seeds were sent to 25 foreign countries and to 9 states of the United States and others in Puerto Rico. In the foreign countries 29 researchers received 19 sets of P. vulgaris and 20 sets of V. unguiculata multiple disease resistant lines. In the United States 13 researchers received 13 sets of P. vulgaris and 5 sets of V. unguiculata multiple disease resistant lines. In Puerto Rico 6 researchers received 5 P. vulgaris and 4 V. unguiculata multiple disease resistant lines.

5. Release of Germ Plasm.

Notice to plant breeders of the release of three dry bean hybrids with multiple disease resistance characteristics, USDA/ARS, January 4, 1974.

Notice to plant breeders of the release of fourteen selected rust resistant bean lines, USDA/ARS, March 11, 1974.

8. Project Design and Methods.

There are four major activities, all of which contribute to the realization of the research objective of controlling diseases and insects of beans, cowpeas, and other food legume crops in the tropics.

a. Virology studies

This activity will phase out in FY-76 with the incorporation of an ultramicrotome facility into the electron microscope work, and the refinement of the "air brush" technique for inoculating plants with a specific virus. Both of these techniques will facilitate the determination of resistance in the plant breeding phase.

b. Control of Fungus and Bacterial Diseases

A number of commercial fungicides and bactericides have already been tested for controlling the common diseases of legumes in the tropics. Further tests on the application time and rate will be made, and new experimental fungicides will be included in the evaluations. Also to be included will be any new strains of diseases which are divulged. Determinations to be made of varieties which demonstrate consistent resistance to diseases.

c. Entomology

This activity will parallel item b., above, as it relates to insect attacks and insecticides. An added element will be the study of natural

enemies of the major insects which attack legumes. The scientists will endeavor to identify varieties which are most resistant to insect attacks.

d. Plant Breeding

Varieties or lines of legumes which possess good cultural characteristics will continue to be crossed with those types identified for their disease and insect resistance (items b. and c., above) in the hopes of combining all of the desirable traits into a few varieties which would then be tested on a worldwide basis.

Graduate students will be trained in the various functions involved in this research program. Inputs for each activity are included in the Work Plan below.

9. Work Plan.

a. Virology: This subsection will be completed with the end of FY 1976. This year's activities will include further characterization by electron microscopy and the use of an ultramicrotoma attachment to make ultrafine sections of plant tissue to determine the existence and type of virus active in the plants.

An electron microscopist will be recruited for six months to train UPR staff in the expert use of the electron microscope and its accessories. Five research assistants are expected to be trained.

Dr. Karl Maramorósh will serve as consultant in the evaluation of the Virology Section Research.

The project developed "air brush" technique of inoculating plants with a specific virus for positive infection to determine positive resistance will be further refined and UPR and MITA staff trained in its use.

Two publications are planned for the year, one on the mechanical inoculation with the golden yellow mosaic virus and one on Euphorbia virus as related to beans.

Current project staff and equipment either on hand or being made available will meet subsection research needs. To train staff in nutron microscopy a Spanish speaking expert from Brazil has been located and is available for a six-month's training program.

Six professional staff and three technical staff providing 43 m/m with 30 m/m of labor will provide a total of 73 man/months of efforts during this funding period. Costs for the total budget are $78,COO.

b. Control of Fungus and Bacterial Diseases: Trials will be expanded to control diseases of legumes other than beans and cowpea. Of particular interest is pigeon pea (Cajanus, cajan) and canker diseases caused by the fungi Phana Cajan, Phylerphthard parasitica, and Balryodypladia.

(1) Work Plan 1976-77.

(a) Common Bacterial Blight of Beans.

Trials will be conducted in the field, both at the Isabela and Lajas Substations in order to establish how effective are the fungicides

(bactericides) Copper 53 and Kocide 101 in controlling common bacterial blight. A new fungicide (Bactericide), Nabac 25, will also be tested against the disease. In vitro tests in the laboratory will also be conducted in which this bacterial pathogen will be exposed to each of the three above-mentioned chemicals as well as to any other newly developed bactericide on hand.

(b) Rust of Beans.

Two experiments will be established, one at the Isabela and the other at the Lajas Substation in which Plantvax and Dithane M-45 will be tested against bean rust. A third fungicide, Triforine, will also be tested. Experimental designs and methodology will be essentially the same as those employed for previous trials.

(c) Powdery Mildew of Cowpea.

In spite of the perfect control displayed by Benlate on powdery mildew for the first two field experiments conducted to screen various fungicides against this disease, it failed to effectively protect the foliage of cowpea during a third trial. Therefore, an additional trial must be conducted in order to establish if failure of this fungicide to protect against powdery mildew is due to inactivation of the chemical by adverse storage conditions or due to the development of new physiologic races of the fungus resistant to the chemical. The trial will be established at the Isabela Substation. The experiments for the detection of races resistant to Benlate will be conducted in the greenhouse.

(d) In Vitro Screening of Chemicals

Laboratory tests are underway in which both EL 370 and Benlate are tested against the fungus Corynespora cassiicola. Other fungicides and bactericides to be tested are Nabac 25, Kocide 101 and Daconil either on C. cassiicola or

on Cercospora spp. and Xanthomonas phaseoli. Both dry weights and radial growth of these microbial pathogens will be recorded for each chemical under study.

(e) Physiologic Races of Bean Rust

Bean leaves infected by U. appendiculatus will be collected from all the bean growing areas of the Island as well as from experimental plots established at the Substations. This material will be in turn purified in the greenhouse by employing cultivars which are highly susceptible to the disease. At least 20 bean differentials of those obtained from United States, Brazil, Colombia and Australia will be exposed to the material collected throughout the Island.

(2) Work Plan 1977-78.

(a) Complete the work initiated in 1975-76 and 1976-77 on chemical control of those diseases which are endemic on both beans and cowpeas.

(b) Find means of control for those diseases reported as new to beans and cowpea in Puerto Rico

(c) Test newly developed pesticides (fungicides and bactericides) against endemic as well as against new diseases of both beans and cowpea in the laboratory, greenhouse and under field conditions.

(d) Initiate research directed to control diseases of legumes other than cowpea and beans, such as pigeon peas and chickpeas. An important disease of pigeon peas in Puerto Rico is stem canker caused by the fungus Phytophthora parasitica.

(3) Work Plan 1978-79.

Continue research directed to control diseases of edible legumes, with special emphasis on those which represent a menace to the economic production

of these legumes under cultivation.

To continue testing fungicide and bactericide as they are released by the chemical companies.

Eight professional staff and three technical staff plus 12 m/m of labor provide a total of 54 m/m for FY 76 and 95 m/m in FY 77 & 78. Total budget costs are $70,000 in 1976, 114,000 in 1977 and $122,000 in 1978.

Major equipment to be purchased in FY 76 includes, a growth chamber, transfer chamber, incubator, two dissecting scopes and a hygrothermograph. No further equipment needs are foreseen through the project life.

(4) Expected Products and Time Frame for Accomplishment.

(a) Information in 1977 on the control of bacterial blight of beans, caused by Xantomanas phaseoli via the fungicides and/or bactericides, basic copper sulphate, copper hydroxide, and Nabac 25.

(b) Information in 1977 on the control of rust of beans, caused by Uromyces appendiculatus, via the fungicide manzoceb, oxathiin (Plant Vax) and the systemic compound Triforine.

(c) In 1977, an explanation of why the systemic fungicide benomyl, which had provided excellent control of powdery mildew of cowpea, did not control the disease in the last test conducted at the Isabela Substation.

(d) An in vitro evaluation of compounds for control of the target spot (cowpea) and bacterial blight (beans) causal organisms (1978).

(e) Indications in 1978 on the races of the bean rust pathogen present in Puerto Rico.

(f) A screening of cowpea accessions for resistance stem canker-inciting pathogens (1978).

c. Work Plan - Entomology - 1976-78.

(a) Continue field tests for the screening of new selections and/or varieties of beans and cowpeas to determine the presence of resistance to the major insect pests, particularly, to the leafhopper , Empoasca fabae, to the leafminer, Liriomyza sativae and to the dry seed weevil, Acanthoscelides obtectus on beans, to the bean beetle , Cerotoma ruficornis on beans and cowpea and to the cowpea weevil, Chapcodermus ebeninus, and to the dry seed weevil , Callosobruchus chinensis on cowpea. This screening should continue for at least 1976-77 and 77-78.

(b) Conduct field test to evaluate insect attack and damage on selected varieties of beans and cowpea. Efforts will be made to determine the effect of different levels of insect populations on yield. This will be started this year for the leafhopper on two varieties of beans, one susceptible and one resistant. Similar tests will be conducted during the following three years in order to determine the insect population causing economic damage.

(c) Field test will be initiated with existing commercial varieties of pigeonpeas to evaluate insect damage, particularly of pod-borers (Heliothis spp.) at different planting time through the pigeon pea season. For this, eggs of Heliothis will be counted at pod setting in all planting through the season to determine the insect damage at different levels of egg infestation. This should be done for at least three years in order to obtain reliable data to predict insect damage based on egg counting at pod setting which is the time to decide on control measures.

Based on the above results insecticide trials could be done (probably after 3 years of data) for the refinement of control measure decision (timing) Efforts will be made to determine the natural enemy complex of Heliothis

larvae in Puerto Rico, and eventually, its efficiency on control. The effect of recommended insecticides on natural enemies will, also, be studied.

(d) Continue field plot, shade house and laboratory studies to provide information on the natural enemy complex of the leafminer, Liriomyza sativae. These studies should continue for at least 3 years. Once the potential enemies are identified, the efficiency of these should be determined as well as the adverse effect of recommended insecticides.

(e) Continue field test to evaluate chemicals for control of insect pests on the above crops, particularly for the leafhoppers, leafminers, the bean beetle, the cowpea weevil and the dry seed weevil. Emphasis will be given to secure minimum chemical dosages that will control the above mentioned insects.

A staff of three professionals and one technician will be required through the life of the project. They will provide 55 man/months including field and laboratory labor staff in FY 76 and 94 m/m each in FY 77 and 78. A portable area meter and a stereomiscroscope fitted with photography equipment will be major equipment needs in 1976. No other major equipment needs are foreseen. Annual funding requirements are $39,000 in FY 76 and $58,000 in FY 77 and $63,000 in FY 78.

d. Plant Breeding for Resistance.

This portion of the work plan will be presented under the individual species being investigated or to be included in the near future.

(1) Common bean (Phaseolus vulgaris).

(a) Exchange of advanced lines with other bean improvement programs (1976-77).

(b) Incorporate major sources of multiple resistance into one or more populations of manageable size. (1976-77)

(c) Test these populations for reselection of higher accumulated resistances and for favorable agronomic characteristics. (1977-78)

(d) Initiate tests to preserve the highest level of nutritive values with the reselection for high multiple disease resistant types. (1977-78)

(e) Release advanced high yielding disease resistant lines. (1977-78)

(f) Determine the genetic base and inheritance of resistance to some of the diseases tested. (1977-78)

(2) Cowpeas and Yardlong (Vigna unguiculata and sesquepedalis).

(a) Continue crossing and reselection for the accumulation of multiple disease resistance. (1976-77)

(b) Initiate breeding program for the incorporation of yield and quality characteristics of adaptable commercial types into the multiple disease resistant material. (1976-77-78)

(c) Develop cooperative testing of advanced disease resistant lines for adaptability and yield with other tropical countries. (1976-77)

(d) Release improved high yielding disease resistant cowpeas and yard long beans. (1977-78)

(e) Incorporate male sterility into breeding lines and populations. (1977-78)

(3) Tepary Bean (Phaseolus acutifolius.

(a) Obtain germ plasm from areas where the tepary is native or in cultivation. (1976-77)

(b) Evaluate for disease resistance, yield and adaptability under tropical conditions. (1977-78)

(c) Cross and select for multiple disease resistance. (1977-78)

(4) Scarlet Runner Bean (Phaseolus coccineus)

(a) Increase germ plasm base through acquisitions and collections. (1976-77)

(b) Screen for multiple disease resistance through the formation of separate bush and vine type composites or populations. (1976-77)

(c) Develop multiple disease resistant types for transfer to P. vulgaris. (1976-77)

(d) Isolate important agronomic and morphological characteristics into compatible lines from which they can be transferred to P. vulgaris. (1976-77)

(e) Develop commercial types for adaptability and yield testing. (1977-78)

(5) Lima Bean (Phaseolus lunatus).

(a) Increase germ plasm base through acquisitions. (1976-77)

(b) Continue screening for multiple disease resistance to reduce the number of lines to a more manageable quantity. (1976-77)

(c) Test advanced lines for their range of adaptability and yield (1977-78)

(6) Pigeon Pea (Cajanus cajan).

(a) Cooperate with the University of Puerto Rico on the important international disease problems. (1976-77-78)

Priority and Time Distribution for Principal Research Personnel

Crop	Priority 10=high	Pathologist % of Time	Breeder % of Time
P. vulgaris	10	30	50
V. unguiculata	9	30	20
V. unguiculata sesquipedalis	6	10	10
P. acutifolius	3	10	10
P. coccineus	3	10	10
P. lunatus	3	10	--
C. cajan	2	--	--

Nine professional and four technical staff will be assigned to the project. Counting assigned laborers a total of 195 m/m will be used in FY 76 and 334 each in FY 77 & 78. Projected funding requirements are $139,000 in FY 1976, $223,000 in 1977 and $237,000 in 1978. Special equipment needs will consist of field cultivators, a portable bean plot thresher, microscopes and sprayers.

10. General Appraisal.

The 1974 PAR indicated progress was as planned and no major production or administrative problems had arisen. Transitional problem of transferring the project to UPR leadership had essentially been solved. Some divergence and lack of communication still existed and more staff meeting and improved exchange of information on each team member's activities was recommended.

Broadening the scope of the project to include other grain legumes was also recommended. As facilities, time and staff permit this is being accomplished.

As part of the outreach effort, including more LDC graduate students as research assistants on the project was suggested.

In the 1975 project review progress was noted in all of the 1974 recommendations. Some work is now being done or planned on pigeon pea, yard long bean and lima beans. Three graduate students have been assigned to the project and improved communication was evident.

The 1975 review again noted good progress on research objective. Virology studies have progressed to the point that they can be terminated at the end of FY 1976. With more proven results being available increased outreach and training activities can be started. Also closer coordination with the soybean project and exchanges of pertinent information was suggested.

In summary, reviews indicate a successful project on schedule with objectives being met.

11. Environmental Impact.

The overall aim of this research project is to increase the food availability to the people of the LDCs. It hopes to accomplish this by reducing losses presently caused by diseases and insects. Ideally, biological control methods will be identified, - barring this, various chemical controls will be indicated. In either case, the effects of other biological forms or of chemicals will be taken into account before any recommendations are made, so that any possible adverse environmental effects will be duly considered.

Further grain legumes properly inoculated fix nitrogen from the air to essentially meet plant requirements. A residual is left on root nodules to reduce the nitrogen requirement for future crops. This results in a lowered requirement for chemical nitrogen, saves fossil based fuels and reduces soil and water pollution. The benefits to be derived from this work are not biased toward any particular economic or social segment of the population of LDCs.

Milestone Life of Project Schedule

Objective/Product	Extension of Project Start FY 1976	FY 1977	Project Completion FY 1978
A. Virology Studies	(S)----------(C)		
1. New virus characterization	(S)----------(C)		
2. Ultra _____ activity	(S)----------(C)		
3. Electron microscope training	(S)--------(C)		
4. Training in manual "air brush" virus inoculation	(S)--------(C)		
5. Data Publication Activity	(S)----------(C)		
B. Fungi & Bacteria Diseases	(S)----------	----------	----------(C)
Powdery Mildew Studies	(S)----------	----------	----------(C)
Leaf Blight Studies	(S)----------	----------	----------(C)
Leaf spot studies	(S)----------	----------	----------(C)
Rust studies	(S)----------	----------	----------(C)
Natural means of control		(S)----------	----------(C)
New disease studies		(S)----------	----------(C)
Other Grain Legume Studies		(S)----------	----------(C)
C. Entomology	(S)----------	----------	----------(C)
1. Bean and cowpea screening for major insect resistance.	(S)----------	----------	----------(C)
2. Determine economic level of insect populations.	(S)----------	----------	----------(C)
3. Pigeon pea screening for insect resistance levels. Egg count and natural enemies will be studied.	(S)----------	----------	----------(C)

Milestone Life of Project Schedule (Cont'd)

Objective/Product	Extension of Project Start FY 1976	FY 1977	Project Completion FY 1978
C. 4. Evaluate chemical control of major insects	(S)----------	----------	----------(C)
D. Plant Breeding			
Common Bean			
1. Exchange bean lines with other improvement programs and incorporate multiple resistance in one or more populations	(S)----------	----------(C)	
2. Select for favorable agronomic characteristics and high nutritive values in multiple disease resistant bean types.		(S)----------	----------(C)
3. Release most promising lines		(S)----------	----------
Cowpea & Yard Long			
4. Develop multi-resistance and commercial quality	(S)----------	----------	----------(C)
5. Develop cooperative breeding programs and release promising new lines		(S)----------	----------(C)
Tepary Bean			
6. Increase germ plasm bank and disease resistance and quality characteristics	(S)----------	----------	----------(C)
7. Cross and select for multi disease resistance		(S)----------	----------(C)
8. Increase germ plasm base and screen for multi disease resistance and commercial quality traits.	(S)----------	----------	----------(C)

Milestone Life of Project Schedule (Cont'd)

Objective/Product	Extension of Project Start FY 1976	FY 1977	Project Completion FY 1978
9. Develop resistance and agronomic traits in lines compatible for transfer to common bean (P. vulgaris) Lima Bean		(S)----------	----------(C)
10. Increase germ plasm, screen for desired traits, test advanced lines for range of adaptability and yield. Pigeon Pea	(S)----------	----------	----------(C)
11. Screen available material and cooperate closely with UPR staff in developing commercially acceptable varieties	(S)----------	----------	----------(C)