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9. ABSTRACT

The objectives of this project are to investigate and develop methods for controlling diseases and insects that attack selected food legumes adapted to the tropics, particularly beans and cowpeas. The focus is on improvement of production through control of insects and of viruses, bacteria, fungi, nematodes, and mycoplasma. A summary of accomplishments during the project year: A new bean strain of cucumber mosaic virus (CMV) was fully characterized. Electron microscopy studies showed that the new bean virus was related to CMV. A previously unreported mosaic virus of Canavalia maritima was characterized through use of such criteria as host range, indicators, serology, physical properties, vector specificity, and electron microscopy. The whitefly-transmitted mosaic virus of Jatropha gossypifolia was found to affect beans, soybeans, and Jacquemontia tamnifolia. However, Bemisia tabaci race jatrophae, the vector, will not survive on the leguminous hosts and Jacquemontia. A new virus was discovered to be affecting Poinsettia geniculata = Euphorbia prunifolia in the Isabela area. The virus will affect beans, soybeans, tobacco, and Datura stramonium but is not capable of infecting Rhynchosia minima. It also fails to provoke the formation of enations on Virginia 12 tobacco. The virus was transmitted mechanically to D. stramonium. This entity seems to be related to the Brazilian mosaic virus of E. prunifolia. The fungicides chlorothalonil, mancozeb, dinocap, and benomyl controlled foliar diseases of cowpea, such as powdery mildew (Erysiphe polygoni) and leaf spots (Corynespora cassiicola, Cercospora spp.). Dinocap was very effective against powdery mildew during the dry season, but failed to protect the plants during rainy weather. Dosages of benomyl as low as 1/4 #/A applied biweekly were enough to prevent

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infection by E. polygoni, C. cassiicola, and Cercospora spp. Both basic copper sulfate and copper hydroxide at the rate of 1 #/A controlled common bacterial blight of beans (Xanthomonas phaseoli). Bean rust (Uromyces appendiculatus) was controlled by mancozeb, Plantvax, and Triforine at 1 #/A. The last two fungicides are systematic are were applied every 14 days. Isolates of Xanthomonas from beans and cowpeas displayed the following types of pathogenicity to these two crops: virulent-virulent, virulent-avirulent, avirulent-virulent, and avirulent-avirulent. Isolates of Xanthomonas phaseoli var. fuscans when inoculated to cowpeas and beans very frequently lost their capacity to produce pigment. Soil and root samples taken to determine the nematodes associated with beans and cowpeas indicated the presence of several known and suspected plant-parasitic species. The most common genera found were Rotylenchulus, Helicotylenchus, Meloidogyne, Pratylenchus, Tylenchus, Aphelenchus, and Aphelenchoides. Field tests on the use of promising insecticides with beans and cowpeas were conducted, but no conclusive results were obtained, sometimes because of low insect infestations, and on other occasions, because of heavy rains after applications. Evidence of plant resistance to the bean leafhopper (Empoasca fabae) was found in eight selections of the white bean cv Bonita. Colored cvs (Rayada, Jamaica, Marca Diablo, and Pompadour) were very susceptible to leafhopper attack. Yields of susceptible cultivars were very drastically reduced. Preliminary evidence on the existence of cowpea cultivars resistant to the cowpea weevil, Chalcodermus ebeninus, was obtained. A possible varietal resistance was also found on bean cultivars Sin Fibra and Galana to the bean weevil, Acanthoscelides obtectus (Say). Rust-resistant bean lines were obtained through naturally occurring cross-pollination in the field. Some of these lines have proved resistant against a wide range of rust races endemic in the tropics. Bean cultivars with multiple virus resistance were developed through field cross-pollinations. Several bean cultivars have been selected for adaptability to warm humid lowland tropics, insensitivity to short daylength, multiple disease resistance, and yield. The screening of the International Cowpea Disease Nursery for cowpea mosaic virus resistance resulted in the selection of several cultivars resistant to the highly pathogenic strain of the virus present in Puerto Rico. The research findings in the virology phase of the Project have been made available to CIAT, Cali, Colombia (the world center for improvements of Phaseolus). A central bank of seed of diagnostic plant species is being established at the Institute as a direct result of efforts in the Project, coupled with those of investigators from elsewhere, who met in Puerto Rico in June, 1974, in a workshop on tropical diseases of grain legumes.

ANNUAL REPORT

IMPROVEMENT OF TROPICAL PRODUCTION OF BEANS AND COWPEAS THROUGH DISEASE AND INSECT CONTROL

January 1 - December 31, 1974

NOT FOR PUBLICATION

Prepared by

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

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Washington, D. C.

REPORT SUMMARY

A. 1. Project Title and Contract Number: "Improvement of Tropical Production of Beans and Cowpeas thru Disease and Insect Control" Contract No. AID/CM/ta-C-73-26.

2. Principal Investigators:

Julio Bird, Pedro L. Meléndez, Carlos Cruz, Jessé Román (Agricultural Experiment Station, University of Puerto Rico, Mayaguez Campus, P.O. Box H, Río Piedras, Puerto Rico 00928), Nader G. Vakili, George F. Freytag and Walter J. Kaiser (Mayaguez Institute of Tropical, Southern Region ARS, USDA, P.O. Box 70, Mayaguez, Puerto Rico 00708).

Dr. Walter J. Kaiser was transferred to a position in Nairobi, Kenya, on 4 April 1974; Dr. George F. Freytag joined the Project staff on 1 September 1974.

3. Contract Period (as ammended): 14 May 1973 to 31 March 1975.

4. Period covered by report: 1 January 1974 to 31 December 1974.

5. Total AID funding of contract to date: $441,073.

6. Total expenditures and obligations through previous contract year: $115,665.

7. Total expenditures and obligations for current contract year: $325,408.

8. Estimated expenditures for next contract year (1 April 1975 - 31 March 1976): $385,426.

B. Narrative Summary of Accomplishments and Utilization:

Dry-beans (Phaseolus vulgaris) and cowpeas (Vigna unguiculata) are an essential, and in many instances the only source of protein for millions of people in the humid tropics. The increase in human population brings about further dependence on these and other related grain legume To provide a reasonable assurance that an adequate supply of these basi grains will be available to satisfy the elementary protein needs of the immediate, short, and long term future, it becomes imperative to increa production of these crops in the tropical areas of consumption. Contro of diseases and insects of these crops is a fundamental aspect of the battle to improve production. Work on this Project, now under the sole contractual responsibility of the University of Puerto Rico, evolved as an integrated effort of the former USDA and University components, and permitted significant progress towards the achievement of its objective. A summary of the accomplishments of the year follows:

The new bean strain of cucumber mosaic virus (CMV) was characterized fully. Electron microscopy studies indicated that, ultrastructurally, the new bean virus was related to CMV. A previously unreported mosaic virus of Canavalia maritima was characterized using criteria such as host range, indicators, serology, physical properties, vector specificity, and electron microscopy. The causal agent seems to be new, although perhaps related to one aphid-borne cowpea mosaic virus studied by Zettler in Florida. The whitefly-transmitted mosaic virus of Jatropha gossypifolia was found to affect beans, soybeans and Jacquemontia tamnifolia. However Bemisia tabaci race jatrophae, the

vector, will not survive on the leguminous hosts and Jacquemontia. A new virus was discovered affecting Poinsettia geniculata = Euphorbia prunifolia in the Isabela area. The virus will affect beans, soybeans, tobacco and Datura stramonium but is not capable of infecting Rhynchosia minima. It also fails to provoke the formation of enations on Virginia 12 tobacco. The virus was transmitted mechanically to D. stramonium. This entity seems to be related to the Brazilian mosaic virus of E. prunifolia.

The fungicides chlorothalonil, mancozeb, dinocap and benomyl controlled foliar diseases of cowpea, such as powdery mildew (Erysiphe polygoni) and leaf spots (Corynespora cassiicola, Cercospora spp.). Dinocap was very effective against powdery mildew during the dry season, but failed to protect the plants during rainy weather. Dosages of benomyl as low as 1/4 #/A applied biweekly were enough to prevent infection by E. polygoni, C. cassiicola and Cercospora spp. It is suspected that a new race of E. polygoni capable of thriving under high relative humidity and rain is present in the field. Both basic copper sulfate and copper hydroxide at the rate of 1 #/A controlled common bacterial blight of beans (Xanthomonas phaseoli). Bean rust (Uromyces appendiculatus) was controlled by mancozeb, Plantvax and Triforine at 1 #/A. The last two fungicides are systemic and were applied every 14 days.

Isolates of Xanthomonas from beans and cowpeas displayed the following types of pathogenicity to these two crops: virulent-virulent, virulent-avirulent, avirulent-virulent and avirulent-avirulent. Iso-

lates of Xanthomonas phaseoli var. fuscans when inoculated to cowpeas and beans very frequently lost their capacity to produce pigment. A Xanthomonas culture, virulent to cowpea and with capacity to produce a distinct blackish pigment, was isolated from a cowpea seedling inoculated with a non-pigment producing culture. Phaseolus vulgaris cultivars mainly developed leaf blight symptoms and Vigna unguiculata cultivars mainly developed stem canker when both species were inoculated with the same Xanthomonas culture.

Soil and root samples taken to determine the nematodes associated with beans and cowpeas indicated the presence of a number of known and suspected plant-parasitic species, among which Rotylenchulus, Helicotylenchus, Meloidogyne, Pratylenchus, Tylenchus, Aphelenchus and Aphelenchoides were the most common nematode genera found. Additional data is needed to determine the degree of resistance or susceptibility of the varieties or accessions examined to any of the above mentioned nematodes.

Field tests were performed with beans and cowpeas to determine the effectiveness of promising insecticides on the control of the most important insects of these crops. Twenty six cultivars or lines of beans and cowpeas were planted to observe differences on susceptibility to destructive insects. No conclusive results were obtained with the insecticides tested due, in part, to a low insect infestation and, in other occasions, possibly to heavy rains after application of treatments. Evidence of plant resistance to the bean leafhopper (Empoasca fabae) was found in 8 selections of the white bean cv Bonita. Colored cvs (Rayada, Jamaica, Marca Diablo and Pompadour) were very susceptible to leafhopper attack.

Yields of susceptible cultivars were very drastically reduced. Preliminary evidence on the existence of cowpea cultivars resistant to the cowpea weevil, Chalcodermus ebeninus was obtained. A possible varietal resistance was also found on bean cultivars Sin Fibra and Galana to the bean weevil, Acanthoscelides obtectus (Say).

Rust resistant bean lines were obtained through naturally occurring cross-pollination in the field. Some of these lines have proved resistant against a wide range of rust races endemic in the tropics. Bean cultivars with multiple virus resistance were developed through field cross-pollinations. A number of bean cultivars have been selected for adaptability to warm humid lowland tropics, insensitivity to short daylength, multiple disease resistance, and yield.

The screening of the International Cowpea Disease Nursery for cowpea mosaic virus resistance resulted in the selection of several cultivars resistant to the highly pathogenic strain of the virus present in Puerto Rico.

The research findings in the virology phase of the Project have become available to the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia (the world center for improvement of Phaseolus). A central bank of seed of diagnostic plant species is being established at the Institute as a direct result of efforts in the Project, coupled to those of investigators from other parts of the world who in met in Puerto Rico in June 1974 in a workshop on tropical diseases of grain legumes.

Notices to plant breeders on the release of three dry bean hybrids with multiple disease resistance characteristics and of 14 selected rust resistant lines bean were published. Seeds of released cultivars were sent to cooperators and interested researchers in 25 foreign countries, 9 states of the United States and others in Puerto Rico. Information was also disseminated via publications, papers and seminars.

PERSONNEL

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Mayaguez Institute of Tropical Agriculture (MITA)

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A. GENERAL BACKGROUND

Hunger and malnutrition in the tropics constitute one of the major world problems. Its prevalence could be reduced by increased production of improved quality food. Edible legumes, such as field beans and cowpeas are good sources of cheap nourishing protein. However, relatively little is known about the diseases and insects affecting these and other edible leguminous crops in the tropics. In many instances basic information relating to tropical diseases, the predisposing factors, and the vectors, if any, are little known. Rarely are economic control measures available to the grower. Thus, the information base which supports production of these crops is entirely inadequate.

This Project is intended to contribute to the development of the information and materials indispensable for improving the production of beans and cowpeas in the tropics, particularly in the humid American tropics. To fulfill these aims, research is in progress in the areas that follow: (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 Experiment Station of the University of Puerto Rico, Mayaguez Campus, at facilities located in Río Piedras and Mayaguez and in various Substations;

in the Mayaguez Institute of Tropical Agriculture, a USDA research unit; and cooperatively in various Central American countries, and at the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.

B. STATEMENT OF PROJECT OBJECTIVES AS STATED IN THE CONTRACT

The major objective of this Project is to investigate and develop methods for controlling diseases and insects of selected food legumes adapted to the tropics, particularly beans and cowpeas. The primary focus will be on improvement of production through disease (viruses, bacteria, fungi, nematodes and mycoplasma) and insect control. The program will receive complementary input from work carried out by the University of Puerto Rico in biology, nutrition, genetics, and other sciences in the tropical environment.

C. CONTINUED RELEVANCE OF OBJECTIVES

The objective stated in the Contract, i.e., "to investigate and develop methods of control of limiting diseases and insects of selected food legumes adapted to the tropics, particularly beans and cowpeas", is still relevant. Research efforts in all phases of the Project are aimed to the accomplishment of this objective.

D. ACCOMPLISHMENTS TO DATE

1. Findings

A. Virus Diseases

Besides other phytopathogenic viruses, a new whitefly-transmitted agent (*Euphorbia prunifolia* mosaic virus) was studied. So far, seven whitefly-transmitted agents have been characterized and their relative effects on important crops such as beans, cowpeas, and other valuable legumes determined. 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.

The recopilation of data presented at the Puerto Rico legume disease workshop into a volume will be of great value to those working with legume viruses in the tropics.

B. Chemical Control of 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 1/4 lb per acre, applied biweekly, were enough to prevent infection by Erysiphe polygoni, the causal agent of powdery mildew, and by 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 fact that the fungicide benomyl in dosages as low as 1/4 lb per acre effectively controlled foliar diseases of cowpea must be considered of great significance since, besides increasing yields, both the concentration and number of applications needed to secure good control were half of those needed when other fungicides, such as mancozeb and chlorothalonil, were employed. Therefore the use of this product, provided pesticide regulations are met in Puerto Rico, as well as in other tropical and subtropical countries, is highly recommended. By using this chemical to protect his plantings, a cowpea grower in Puerto Rico would be able to save as much as one-hundred-twenty-five ($125.00) dollars per acre per crop. Moreover, the amount of pesticide incorporated into the soil environment would be drastically reduced, thus helping to keep contamination down to a minimum.

Benomyl has been successfully employed to control the same diseases (powdery mildew, leaf spot and target spot) on crops other than cowpea in the United States, South America, Canada and India. It is claimed that

continuous use of the chemical induces mutation by the pathogen and the appearance of races resistant or tolerant to the fungicide. Since mancozeb, chlorothalonil and dinocap are as effective as benomyl, although at higher concentrations, these compounds could be combined in sprays with benomyl in order to reduce the chances for new races of the pathogens to develop.

The fungicides, Kocide 101 (copper hydroxide) and Copper 53 (tribasic copper sulfate) at the rate of 1 pound per acre were very effecti in controlling common bacterial blight (Xanthomonas phaseoli) of bean o cultivar R-19, as indicated by the low disease indexes evident on this cultivar when exposed to these compounds. Common bacterial blight of beans, judging by our research results, is not a limiting factor in bean production no matter how heavily infected the plants are if attack takes place when pods are already developed. However when a heavy attack occurs at an early stage of pod development total crop loss is to be expected. Similar observations have been reported by researches from the United States (Michigan, Colorado, Florida) and Mexico. Work conducted in these countries employing copper compounds such as basic copper sulfate, copper hydroxide and others showed that these compounds are very effective in controlling the disease. Investigators claimed, however, that increased yields are obtained only when the fungicides are used to control early attacks by the bacterial pathogen.

The systemic fungicides Plantvax and Triforine at the rates of 2 and 1/2 lb per acre, respectively, and mancozeb at the rate of 1 lb per acre protected the foliage of bean cultivars Blanca del País and Bountiful

against rust, caused by Uromyces appendiculatus. However, results with oxycarboxin (Plantvax) were erratic. This fungicide, due to its systemic properties (longer residual effects) is highly recommended by workers engaged in chemical control of bean rust in other countries. Triforine, another systemic, behaved more or less similarly. More research is needed in order to establish the role of these compounds in controlling bean rust in the tropics. Mancozeb, although effective in higher dosages, always protected the bean foliage against the disease.

C. Nematology

Work on the nematology phase was 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.

D. Insect Control

The most significant findings to date have been the identification of the major insect pests of beans and cowpeas and the evidence of resistance or tolerance in some cultivars to some of these insect species. 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 sativae, the pod borers, Maruca testulalis and Etiella zinckenella, aphids and cutworms. Other species observed on beans were the vegetable

leafminer, Liriomyza sativae, the bean beetle, Cerotoma ruficornis, the sugar cane weevil, Diaprepes abbreviatus, the lesser cornstalk borer, Elasmopalpus lignosellus, the leaf roller, Urbanus proteus, and other leaf tiers.

The leaf miner, the bean beetles and the pod borers also are species of potential economic importance. Populations of these insects should be observed carefully since an outbreak of any of them could reduce yields significantly.

These findings will facilitate 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 made available to the plant breeder.

E. Virulence Study of Xanthomonas Isolates

A virulence study with Xanthomonas isolates indicated that 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 studies suggested that: (a) culture #9563 was a mixture of X. phaseoli and X. vignicola, (b) it was contaminated with X. vignicola during increase, (3) 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 tests 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.

F. Beans - Disease Resistance, Yield and Adaptability Trials

a. Red Beans

1. 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 País, and French Horticultural 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 will be grown in replicated yield trials during 1975

2. Others

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, soil-borne disease resistant, daylength insensitive, moderate to high yielding, dark red Mexican, dry bean cultivar that could serve as important parental material for breeding red beans 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.

b. Black Bean Trials

Screening for resistance to soil-borne diseases has become a routine procedure. Soil-borne pathogens caused severe loss among susceptible cultivars during the rainy season, and were a limiting yield factor. The high yielding, multiple disease resistant cultivar 15R-55 proved resistant to soil-borne diseases in bean growing areas of Northern United States.

Whitefly transmitted viruses (WFTV) caused severe loss in yield when infection occurred prior to flowering. However, WFTV were not a limiting factor for yield, if attack occurred 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 produced the highest yields among 12 entries tested. The outstanding results obtained with the advanced breeding lines developed in Puerto Rico (15R-55, 15R-42 and 71-1R-113) are highly stimulating and rewarding.

Bean cultivars varied in their level of susceptibility to web blight. Cultivar 15R-55 had the highest tolerance followed by Mexico-309. However, the latter cultivar, under field stress (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.

c. Rust Resistance Trials

Field trial data suggested that the rust resistant cultivars La Vega, Jamapa, 15R-55, 15R-66, 71-1R-136-BK, and 15R-292 are good candidates for breeding adaptable, multiple disease resistant, and high yielding beans for the lowland tropics.

d. International Rust Resistance Trials

On April 1973, seeds of 22 rust resistant bean cultivars were send to ten countries for tests against endemic rust races. Data from five countries is available, and will appear in the next annual report. Some of the outstanding results were the following:

- 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 at CIAT as one of the parental lines in breeding high yielding disease resistant beans.

Twelve of the 22 cultivars were resistant to all endemic rust races in Australia. Cultivar PR-S-70-15R-87-BK was used in a number of crosses. The analysis of data has indicated the presence of 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 that country.

Cultivars PR-S-70-15R-87-BK and 15R-277-BK were resistant to endemic races in five locations in Costa Rica.

Cowpeas - 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 tests 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. Seven accessions were free from bacterial blight and canker.

H. General Remarks

After five years of research effort, the Puerto Rico project has developed cultivars with multiple disease resistance and superior yield capacity. Continued use of these highly resistant cultivars should result in increased stability and yield in bean production in tropical areas. Meanwhile, Stateside scientists are the major utilizers of the Project's output of disease resistant materials.

The findings presented in this report indicate that the screening and selection program in Puerto Rico has provided several sources of disease resistance which have been widely tested and found to maintain a high degree of resistance and adaptability when compared to other cultivars.

I. Bean Breeding

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

2. Interpretation of Data and Supporting Evidence

A. Virus Diseases

a. Mosaic of Bidens pilosa

The [illegible] virus seems to pose no problems to beans, cowpeas and other valuable legumes judging from the results obtained in mechanical inoculation and insect transmission trials. The virus was transmitted (with difficulty) to Bidens (via aphids - Dactynotus ambrosiae) and by mechanical means and aphids to cucumbers but not to beans nor cowpeas

b. Bean Strain of Cucumber Mosaic Virus

The data on transmission of the bean strain of the cucumber mosaic virus is summarized in Tables 1 and 2. Our conclusions regarding the identity of this new aphid-transmitted (Aphis gossypii) virus of beans (BVBMV) were confirmed by the results of electron microscopy studies carried out by Dr. Roger Lawson (USDA) in Beltsville, Maryland and by serological test conducted in Puerto Rico by Dr. Howard E. Waterworth and our group. Thus it has been properly established that the agent is, beyond doubt, a strain of common cucumber mosaic virus (CMV). The agent is not seed-transmitted under our conditions and its incidence in the field seems to be rather low A full report on the properties of BVBMV was published in the Journal of Agriculture of the University of Puerto Rico and is listed in the publications section (Appendix II - Section K).

c. Mosaic of Canavalia maritima

The mosaic virus of Canavalia maritima was fully characterized on the basis of its symptomatology, host range (Table 3), vector specificity (Table 4), physical properties, serology, and ultrastructure (electron microscopy).

Table 1.-Transmission of the vein banding virus from various sources to different hosts via aphids

Virus source plant / Test plant	Aphid species tested and plants infected over plants inoculated			Symptoms[2/] on infected test plant
	A. craccivora	*A. gossypii*	*D. ambrosiae*	
Phaseolus vulgaris L. var. La Vega / *P. vulgaris* var. La Vega	0/8[1/]	5/6	0/8	VC, ICT, M, VB
Cucumis sativus L. var. Black Diamond / *P. vulgaris* var. La Vega	3/8	14/14	1/6	VC, ICT, M, VB
Cucumis sativus L. var. Black Diamond / *C. sativus* var. Black Diamond	2/4	14/14	0/9	VC, CS, R
Cucumis sativus L. var. Black Diamond / *Vigna sinensis* (L.) Savi ex. Hassk. var. Black	0/12			
Cucumis sativus L. var. Black Diamond / *P. vulgaris* var. Diablo		4/4		VC, ICT, M, VB
Cucumis sativus L. var. Black Diamond / Plantain var. Maricongo (*Musa* sp.)		5/6		LS, M, Ac

1/ Number of plants infected per number of plants inoculated; an equal number of uninoculated control plants were included in each test. None of the control plants developed symptoms of disease.

2/ Key to symptoms:

VC - Vein-clearing
M - Mosaic
CS - Chlorotic spots
R - Ringspots
VB - Vein-banding
ICT - Inward curling of leaf tips
LS - Lenticular spots
Ac - Acronecrosis

Table 2.-Symptoms incited by the vein-banding mosaic virus of beans on a series of selected hosts inoculated mechanically

Family	Species tested	Symptoms[1/]
Amaranthaceae	*Gomphrena globosa* L.	--
Apocynaceae	*Vinca rosea* L.	--
Carduaceae	*Bidens pilosa* L.	--
Cucurbitaceae	*Cucumis sativus* L. var. Black Diamond	VC,M
	Luffa cylindrica (L.) Roemerer	VC,CS,R
	Momordica charantia L.	CS,M
Leguminosae	*Cassia occidentalis* L.	--
	Glycine max (L.) Merr.	--
	Phaseolus aborigeneus Burk.	VB
	P. aconitifolius Jacq.	--
	P. acutifolius Gray, Wright	--
	P. acutifolius Gray, Wright var. latifolius Freeman	--
	P. aureus Roxb.	--
	P. calcaratus Roxb.	--
	P. lathyroides L.	M,VB,P
	P. lunatus L. var. Sieva	VC,M
	P. mungo L.	--
	P. ricciardianus Tenore	--
	P. vulgaris L. var. Columbia	VC,ICT,M,VB
	P. vulgaris L. var. Diablo	VC,ICT,M,VB
	P. vulgaris L. var. La Vega	VC,ICT,M,VB
	P. vulgaris L. var. Santa Ana	VC,ICT,M,VB
	Vigna sinensis (L.) Savi ex. Hassk. var. Black	R,M
Solanaceae	*Capsicum annuum* L. var. Large Bell Hot	VC,M
	Datura metel L.	LCB
	D. stramonium L.	LCB
	Lycopersicon esculentum Mill. var. Floradel	M
	Nicotiana glutinosa L.	VC,R,M,VB
	N. tabacum L. var. Virginia 12	VC,R,M,VB
	Solanum torvum Sw.	OL

1/ Key to symptoms:

VC - Vein clearing
M - Mosaic
CS - Chlorotic spots
R - Ringspots
VB - Vein banding
P - Puckering
ICT - Inward curling of leaf tips
LCB - Large chlorotic blotches
OL - Oak leaf
-- - No symptoms

Table 3.-Host range of the Canavalia mosaic virus as determined by mechanical inoculation

Family	Species tested	Number of plants successfully inoculated over plants treated	Symptoms 1/
Amaranthaceae	Gomphrena globosa L.	0/15	-
Carduaceae	Bidens pilosa L.	0/15	-
Chenopodiaceae	Chenopodium album L.	4/8	NL
	C. amaranticolor Coste & Reyn.	20/20	NL
	C. quinoa Willd.	20/20	NL
	Spinacia oleracea L.	4/8	CS
Cucurbitaceae	Cucumis sativus L. var. Black Diamond	0/48	-
Leguminosae	Cajanus indicus Spreng.	8/20	M,NVN,S
	Canavalia ensiformis (L.) DC.	20/20	Ep,NVN,Ac
	C. gladiata DC.	20/20	Ep,NVN,Ac
	C. maritima (Aubl.) Thou.	40/50	M
	Cassia occidentalis L.	2/8	M
	Crotalaria striata DC.	0/10	-
	Glycine max (L.) Merr. var. Kanrich	25/43	M
	Lupinus luteus L.	4/8	M
	Medicago sativa L.	0/30	-
	Phaseolus aborigeneus Burk.	15/24	M,NVN
	P. acutifolius Gray, Wright	6/17	Ep,Ac
	P. acutifolius Gray, Wright var. latifolius	40/60	Ep,Ac
	P. lunatus L. var. Haba de Tocón	8/16	Ep,Ac
	P. lunatus L. var. Henderson Bush Lima	6/18	M
	P. mungo L.	4/32	M
	P. ricciardianus Tenore	0/40	-
	P. vulgaris L. var. Bountiful	22/39	Y,M
	P. vulgaris L. var. Diablo	13/56	Y,M
	P. vulgaris L. var. La Vega	0/46	-
	P. vulgaris L. var. Topcrop	9/30	NL
	P. vulgaris L. var. U.S. Green Refugee	0/14	-
	Pisum sativum L. var. Perfected Wales	0/25	-
	P. sativum L. var. Perfection	0/25	-
	Trifolium pratense L.	0/30	-
	T. repens L. var. Ladino	0/30	-
	Vicia faba L.	10/90	M
	Vigna aconitifolia (Jacq.) Maréchal	0/35	-
	V. angularis (Willd.) Ohwi and Ohashi	12/28	M
	V. radiata (L.) Wilczek	8/15	M,NVN
	V. umbellata (Thunb.) Ohwi and Ohashi	0/23	-
	V. unguiculata (L.) Walp. var. Black	0/20	-
	V. unguiculata (L.) Walp. var. Early Ramshorn	48/50	M
Solanaceae	Capsicum annuum L. var. California Wonder	0/15	-
	Datura stramonium L.	0/8	-
	Nicotiana glauca Grah.	0/8	-
	N. glutinosa L.	0/8	-
	N. tabacum L. var. Virginia 12	0/8	-
	Solanum torvum Sw.	0/10	-

1/ Key to symptoms: NL-necrotic lesions; CS-chlorotic spots; M-m necrosis; S-stunting; Ep-epinasty; Ac-acronecrosis; Y-yellowing.

Table 4.-Transmission of the *Canavalia* virus to three leguminous hosts via several aphid species

Aphis species tested	Plant species tested and number of plants infected over number of plants inoculated		
	C. maritima	*C. ensiformis*	*V. unguiculata*
Aphis craccivora	4/24, 6/24, 1/6	2/3, 0/9	10/20
Myzus persicae	11/15, 2/6	0/9	
Aphis gossypii	6/28		
Dactynotus ambrosiae	0/6	0/9	

Symptoms on legumes resemble, in general, those incited by bean common mosaic (BCM) and bean yellow mosaic (BYM). The virus has a wide host range within legumes and is capable of inducing the formation of local lesions on Chenopodium quinoa. The Canavalia virus is transmitted rather efficiently by Myzus persicae and less so by Aphis craccivora and A. gossypii. The physical properties conform to those which normally characterize the viruses belonging to the BCM and BYM groups. The results of serological studies do not throw much light on the identity of the Canavalia virus. Tests conducted with fresh and reliable viral antisera have repeatedly failed to disclose any relationship between the Canavalia virus and the following viruses: bean southern mosaic, soybean mosaic, broad bean mottle, cowpea mosaic, clover white mosaic, clover yellow mosaic and tobacco ringspot. Ultrastructurally the virus resembles one aphid-borne cowpea mosaic virus studied by Zettler and associates in Florida. However the local virus is not transmitted, at least under our conditions, through the seed produced by severely affected cowpea plants. The Canavalia virus is easily propagated by aphids to beans, cowpeas, soybeans and other valuable legumes and should be considered as a potentially dangerous malady. A full report on this virus is to be published in a forthcoming volume (Academic Press) on Diseases of Tropical Legumes edited by Julio Bird and Karl Maramorosch.

d. Mosaic of Euphorbia prunifolia

The mosaic of Euphorbia prunifolia, characterized by yellow green mottling and yellow veins, was discovered very recently in Puerto Rico affecting E. prunifolia in a small area surrounding an experimental soybean field in the Isabela Substation. For more than 15 years we had been on the lookout

for the Euphorbia mosaic after studying a report on the existence of such a disease in Brazil. In Isabela most of the cases of mosaic were concentrated in a small area receiving artificial light during the night. Most of the E. prunifolia plants growing some distance away (100 feet or more) from the artificially illuminated soybeans bore no symptoms of mosaic and were devoid of whiteflies. The fact that the mosaic was nowhere to be encountered but on that particular farm raised questions regarding its possible origin. Lately the mosaic has spread all over the Isabela Substation grounds. Was the causal agent brought in with some Brazilian cassava, Manihot utilissima Pohl., introductions (vegetatively propagated), or was the virus transmitted from a local host to E. prunifolia?

Tests conducted under controlled conditions in the greenhouse indicated that the virus was efficiently transmitted by B. tabaci race sidae and that it was capable of infecting Datura stramonium (immune to the Rhynchosia virus), Phaseolus vulgaris, Nicotiana tabacum, Glycine max, as well as seedling plants of the primary host. Further studies will disclose whether it is a new virus in our locality or a strain of one of the locally known rugaceous entities. The local Euphorbia virus can be transmitted by mechanical means to D. stramonium. The virus appears to be closely related to the one reported from Brazil by Costa and Bennett. Once in Datura the virus can be easily (100%) transmitted to plants of the same species. The etiological agent was partially concentrated by differential centrifugation (high and low speeds) as well as by density gradient centrifugation (this last was done by our cooperators. Dr. Karl Maramorosch and associates, at the Waksman Institute of Microbiology, Rutgers University, New Brunswick, New Jersey).

It was visualized via the electron microscope in Puerto Rico as well as by our cooperators in New Jersey. Electron micrographs indicate that the viral particle is icosahedral. The virus was found in negatively stained dip preparations and in ultra thin sections. Sections from unaffected tissues did not contain the aforementioned particles. Supernatant fractions from preparations centrifuged at high speeds (30,000 rpm) were not infective. The causal agent was still active 2 weeks after leaves containing the virus were dehydrated at room temperature (75°F) with the aid of calcium chloride. Highly infective preparations were obtained after the virus was partially concentrated by high and low speed centrifugation.

e. Rhynchosia Mosaic Virus

Studies on the host range of the Rhynchosia mosaic virus and its vector were terminated. These are summarized in Table 5.

f. Cowpea Mosaic Virus

Cowpea mosaic virus, transmitted in Puerto Rico by Cerotoma ruficornis, and possibly by other related species, is very often found affecting cowpeas, in varying degrees, in most plantings. Recently the virus was detected (via serological methods) in soybean plants growing in the vicinity of infected cowpeas at the Isabela Substation. The results of biological tests (host range and indicator plant studies) also showed that cowpea mosaic virus was the causal agent of the mosaic affecting soybeans. The implications of these findings are fairly clear. Cowpeas and soybeans should not be grown in close proximity, and if so proper measures should be taken to avoid spread of mosaic from cowpea to soybean fields via the reported vector. Incidence of the mosaic on soybeans was noted to be high (above 30%) in two cases.

Table 5.-Host range of the Rhynchosia virus and its whitefly vector, Bemisia tabaci race sidae

Family	Species tested	Colonization (+ or -)[1]	Susceptibility to Rhynchosia virus (+ or -)[2]
Caricaceae	Carica papaya L.	-	-
Chenopodiaceae	Chenopodium amaranticolor Coste and Reyn.	-	-
Commelinaceae	Commelina diffusa Burm. F.	-	-
Compositae	Helianthus annus L.	+	-
Convulvulaceae	Ipomoea batatas (L.) Lam.	+	-
	I. quinquefolia L.	+	-
	Jacquemontia pentantha (Jacq. G. Don.	+	-
	J. tamnifolia (L.) Griseb.	+	-
Cucurbitaceae	Cucumis sativus L.	-	-
	Cucurbita moschata Duck. cv del país	-	-
Euphorbiaceae	Croton lobatus L.	-	-
	Jatropha gossypifolia L.	-	-
	J. multifida L.	-	-
	Ricinus communis L.	-	-
Leguminosae	Cajanus cajan (L.) Millsp.	+	+
	Canavalia ensiformis (L.) DC.	+	+
	C. maritima (Aubl.) Thou.	+	+
	Centrosema pubescens Benth.	-	-
	Cicer arietinum L.	-	-
	Crotalaria intermedia L.	-	-
	C. juncea L.	-	-
	C. striata DC.	-	-
	Desmodium tortuosum DC.	+	-
	Glycine max (L.) Merr.	+	+
	Phaseolus angularis (Willd.) W. F. Wright	+	+
	P. adenanthus Meyer	+	-
	P. coccineus L.	+	-
	P. lathyroides L.	+	+
	P. lunatus L.	+	+
	P. trichocarpus C. Wright	+	+
	P. vulgaris L.	+	+
	Rhynchosia minima (L.) DC.	+	+
	R. reticulata (Sw.) DC.	+	+
	Vigna hosei (Craib) Back.	-	-
	V. luteola (Jacq.) Benth.	-	-
	V. repens (L.) Kuntze	-	-
	V. sinensis (L.) Endl.	-	-
Malvaceae	Abelmoschus esculentus (L.) Moend.	+	+
	Althea rosea (L.) Cav.	+	-
	Gossypium hirsutum L.		
	cv Sea Island	+	+
	cv Coast Land	+	+

Table 5.- (Cont.)

Family	Species tested	Colonization (+ or -)1/	Susceptibility to *Rhynchosia* virus (+ or -)2/
Musaceae	*Musa paradisiaca* L.	-	-
	M. sapientum L.	-	-
Phytolaccaceae	*Phytolacca icosandra* L.	-	-
Rubiaceae	*Coffea arabica* L.	-	-
Solanaceae	*Capsicum annuum* L.	-	-
	Datura metel L.	-	-
	D. stramonium L.	-	-
	Lycopersicum esculentum (L.) Mill.		
	cv Marglobe	-	-
	cv Rutgers	-	-
	Nicotiana acuminata Hook	-	+
	N. bigelovii (Torrey) Watson	-	-
	N. bonariensis Lehmann	-	+
	N. clevelandii Gray	-	+
	N. glauca Grah.	-	-
	N. glutinosa L.	-	+
	N. knightiana Goodspeed	-	+
	N. maritima Wheeler	-	+
	N. palmeri Gray	-	-
	N. paniculata L.	-	+
	N. solanifolia Walp.	-	-
	N. tabacum L.		
	cv Beinhart 1000	-	+
	cv Burley 2	-	+
	cv Connecticut All Purpose	-	+
	cv Dixie Shade	-	+
	cv Gigante	-	+
	cv Native Chewing	-	+
	cv Selección Olor	-	+
	cv Turkish	-	+
	cv Virginia 12	-	+
	cv Wisconsin Havana	-	+
	N. tomentosa R. & P.	-	-
	N. trigonophylla Dun.	-	-
	Petunia violacea Lindl.	+	+
	Physalis angulata L.	+	-
	P. floridana Rydb.	+	-
	P. peruviana L.	+	-
	Solanum nodiflorum Dunal	+	+
	S. torvum Sw.	+	-

1/ + denotes that whiteflies bred well, and - denotes that whiteflies failed to breed, or bred poorly, on the particular host.

2/ + denotes that the species was susceptible, and - denotes that the species failed to develop symptoms.

B. Chemical Control of Fungus and Bacterial Diseases

a. Leaf Spot of Cowpea

Data on leaf spot of cowpea caused by Cercospora spp. and target spot caused by Corynespora cassiicola was recorded from the same experiment since symptoms of both diseases are easily distinguishable from each other. Table 6 summarizes the data gathered for both diseases. Apparently, inoculum potential of C. cassiicola was greater than that of Cercospora, as evidenced by the number of spots caused by each pathogen on the host plants However, the number of spots recorded for each fungus on the non-treated controls was significantly greater than that recorded from most of the fungicide-treated plots. Therefore, all fungicides tested effectively controlled leaf spots. According to the data in Table 6, the best fungicide for the control of both diseases was benomyl, since dosages of this chemical as low as 1/4 pound per 100 gallons of water checked both maladies.

Yields from plots treated with mancozeb and chlorothalonil at 4 pounds per 100 gallons of water, and benomyl at 1/2 and 1 pound per 100 gallons of water were significantly greater than yield for the non-treated control.

Control by benomyl is considered of great significance due to the fact that besides increasing yields drastically, both the number of applications and the concentrations were one half those of mancozeb or chlorothalonil. Therefore, by using benomyl to protect his plantings a cowpea grower would be able to save as much as one-hundred-twenty-five ($125.00) dollars per acre per crop. Moreover, the amount of chemical incorporated to the soil environment is drastically reduced, helping to keep contamination down to a minimum.

Table 6.-Disease incidence and yield of cowpea cv Early Ramshorn treated with fungicides to control leaf spots

Treatment		Interval of application (days)	Number of spots per plant		Pounds per acre
			Corynespora	Cercospora	
Mancozeb	- 1.00 lb/100 gal	7	47**	15	1,324
Mancozeb	- 2.00 lb/100 gal	7	26**	6*	1,290
Mancozeb	- 4.00 lbs/100 gal	7	13**	3*	1,393*
Benomyl	- 0.25 lb/100 gal	14	10**	0**	1,256
Benomyl	- 0.50 lb/100 gal	14	32**	2**	1,406*
Benomyl	- 1.00 lb/100 gal	14	17**	1**	1,572**
Chlorothalonil	- 1.00 lb/100 gal	7	142*	55	1,394*
Chlorothalonil	- 2.00 lbs/100 gal	7	62**	3**	1,254
Chlorothalonil	- 4.00 lbs/100 gal	7	139**	5*	1,520*
Check		-	234	56	910

* Significant at the 5% level
** Significant at the 1% level

Table 7.-Disease index and yield of cowpea cv Early Ramshorn treated with fungicides to control powdery mildew

Treatment		Interval of application (days)	Disease index	Pounds per acre
Mancozeb	- 1.00 lb/100 gal	7	28**	296
Mancozeb	- 2.00 lbs/100 gal	7	16**	491
Mancozeb	- 4.00 lbs/100 gal	7	16**	407
Benomyl	- 0.25 lb/100 gal	14	0**	355
Benomyl	- 0.50 lb/100 gal	14	0**	473
Benomyl	- 1.00 lb/100 gal	14	0**	435
Chlorothalonil	- 1.00 lb/100 gal	7	32*	357
Chlorothalonil	- 2.00 lbs/100 gal	7	20**	396
Chlorothalonil	- 4.00 lbs/100 gal	7	16**	366
Check		-	80	244

* Significant at the 5% level
** Significant at the 1% level

b. Powdery Mildew of Cowpea

Data collected from 3 experiments on chemical control of powdery mildew is summarized in Tables 7, 8 and 9. Judging by the disease index, as shown in Table 7 (experiment 1), good control was achieved with all fungicides tested. However, yields from fungicide-treated plots were not significantly higher than those from check plots. Apparently, heavy mildew attack occurred by the end of the growing season when drier conditions favored maximum spore germination and penetration.

In the second experiment (Table 8) infection by the powdery mildew organism took place at an earlier stage of cowpea development. Therefore the check plants were damaged to the extent of becoming almost completely defoliated. Yields of plots treated with dinocap at 1/4 and 1 pound, benomyl at 1/2 pound, and mancozeb at 2 and 4 pounds per 100 gallons of water were significantly greater than yield of the control plots. Yield of 1/2 pound benomyl-treated plots was 5 times greater than that of the control.

The third experiment on chemical control of powdery mildew (Table 9) presented a totally different picture. Regardless of the heavy rain which prevailed throughout the growing season, the plants were severely attacked by the mildew pathogen and total defoliation occurred in the check plots.

Judging by the disease indexes recorded for each fungicide (Table 9), benomyl and mancozeb effectively controlled the disease, but dinocap, which had proven to be very effective under drier conditions, failed in this test to protect the plants. Since mildew attack took place after most of the pods were already developed, the check plots yielded as much as most of

Table 8.-Yield of cowpea cv Early Ramshorn treated with fungicides to control powdery mildew

Treatment	Interval of application (days)	Pounds per acre
Dinocap - 0.25 lb/100 gal	7	416.2**
Dinocap - 0.50 lb/100 gal	7	265.5
Dinocap - 1.00 lb/100 gal	7	459.5**
Benomyl - 0.25 lb/100 gal	14	333.3
Benomyl - 0.50 lb/100 gal	14	544.3*
Benomyl - 1.00 lb/100 gal	14	269.3
Mancozeb - 1.00 lb/100 gal	7	205.3
Mancozeb - 2.00 lbs/100 gal	7	354.0*
Mancozeb - 4.00 lbs/100 gal	7	386.0*
Check	-	109.2

* Significant at the 5% level
** Significant at the 1% level

Table 9.-Disease index and yield of cowpea cv Early Ramshorn treated with fungicides to control powdery mildew

Treatment	Number of application	Disease index	Pounds per acre
Dinocap - 0.25 lb/100 gal	7	88	1,487.8
Dinocap - 0.50 lb/100 gal	7	84	1,367.4
Dinocap - 1.00 lb/100 gal	7	76	1,315.8
Benomyl - 0.25 lb/100 gal	3	12**	1,427.6
Benomyl - 0.50 lb/100 gal	3	8**	1,677.0
Benomyl - 1.00 lb/100 gal	3	4**	1,745.8
Mancozeb - 1.00 lb/100 gal	7	40*	1,804.3
Mancozeb - 2.00 lbs/100 gal	7	20*	1,740.6
Mancozeb - 4.00 lbs/100 gal	7	0**	1,935.0*
Check	-	100	1,522.2

* Significant at the 5% level
* Significant at the 1% level

the fungicide-treated plots, regardless of defoliation. The increased yields, irrespective of treatments, obtained in this trial may be attributed to higher soil fertility of the site selected for the experiment.

With regards to the aforementioned mildew attack, it is an established fact that the disease is checked by abundant rain, but this did not hold true in this instance. Due to this unexpected phenomenon, it is suspected that a race of the pathogen capable of thriving under high relative humidity has developed in the field. Moreover, as mentioned earlier, the fungicide dinocap failed to protect the plants, regardless of the concentration of the chemical employed. Therefore, if a new race has developed, it appears to be resistant to dinocap.

The fungicide benomyl effectively controlled foliar diseases of cowpeas. Therefore its use, provided local pesticide regulations are met, is highly recommended, since the farmer, as mentioned earlier, would save both money and time by applying this chemical. In tests conducted in the Pesticide Residue Laboratory at the Agricultural Experiment Station no residues of the chemical could be detected in the cowpea seed even after employing up to 1/2 pound of the fungicide per acre.

c. Rust of Beans

As indicated in Table 10, all fungicide treatments tested in the experiment established in January failed to protect cultivars Blanca del País and Bountiful from leaf rust. Therefore, there were no significant differences between the yields of fungicide-treated plots and those of the non-treated control.

Table 10.-Yield of bean cvs Blanca del País and Bountiful treated with fungicides to control leaf rust

Treatment	Interval of application (days)	Pounds per acre 1/ Blanca del País	Bountiful
Plantvax - 1.00 lb/100 gal	14	172.2	243.4
Plantvax - 2.00 lbs/100 gal	14	359.5	222.8
Triforine - 0.50 lb/100 gal	14	286.5	344.5
Triforine - 1.00 lb/100 gal	14	357.6	307.0
Mancozeb - 1.00 lb/100 gal	7	245.3	280.8
Mancozeb - 2.00 lbs/100 gal	7	273.3	222.8
Benomyl - 0.25 lb/100 gal	14	295.8	179.7
Benomyl - 0.50 lb/100 gal	14	312.7	237.8
Check	-	202.2	234.0

1/ There were no significant differences among treatments.

Table 11.-Disease index of bean cvs Blanca del País and Bountiful treated with fungicides to control leaf rust

Treatment	Number of application	Disease index Blanca del País	Bountiful
Plantvax - 1.00 lb/100 gal	2	62	38*
Plantvax - 2.00 lbs/100 gal	2	58	42*
Triforine - 0.50 lb/100 gal	2	52*	36*
Triforine - 1.00 lb/100 gal	2	56*	42*
Mancozeb - 1.00 lb/100 gal	4	34**	40*
Mancozeb - 2.00 lbs/100 gal	4	30**	42*
Benomyl - 0.25 lb/100 gal	2	68	46
Benomyl - 0.50 lb/100 gal	2	70	50
Check	-	76	80

* Significant at the 5% level
** Significant at the 1% level

The data from the experiment established in September is summarized in Table 11. According to the disease index, Plantvax at the rate of 2 pounds per acre protected cultivar Bountiful, but failed to protect Blanca del País. Triforine, at the rate of 1/2 pound per acre protected both Bountiful and Blanca del País. Mancozeb effectively protected both cultivars, while benomyl failed to protect them.

ield data for the September experiment is not included. Maturity and harvest of the crop coincided with continuous rains. Excessive moisture affected quality and weight of the seeds adversely.

d. Common Bacterial Blight of Beans

R-19, a cultivar which is highly susceptible to bacterial blight, was used in the tests. Copper hydroxide and basic copper sulfate, each at the rate of 1 pound per acre, controlled the disease, as evidenced by the low disease indexes recorded for the fungicide-treated plots (Table 12 and 13). However, as attack took place when pods were already developed yields in the fungicide treated plots did not increase significantly. Disease severity in both experiments, even in the non-treated plots, was appreciably low in spite of optimum conditions for bacterial infection and multiplication. Therefore, the low yield in experiment 1 (Table 12) should not be totally attributed to bacterial attack.

C. Nematology

Table 14 presents the nematodes isolated from the soil around the roots of beans and cowpeas planted at the Isabela Substation. A total of 12 genera and species of plant-parasitic or suspected plant parasites were found. Of the 3 bean varieties examined, the red bean cv Bountiful

Table 12.-Disease index and yield of bean cv R-19 treated with various chemicals to control common bacterial blight

Treatment		Interval of application (days)	Disease index	Pounds per acre
Copper hydroxide	- 0.50 lb/100 gal	7	37	833
Copper hydroxide	- 1.00 lb/100 gal	7	33*	919
Basic copper sulfate	- 1.00 lb/100 gal	7	53	794
Basic copper sulfate	- 2.00 lbs/100 gal	7	43	880
Benomyl	- 0.25 lb/100 gal	14	43	781
Benomyl	- 0.50 lb/100 gal	14	47	824
Chlorothalonil	- 1.00 lb/100 gal	7	40	840
Chlorothalonil	- 2.00 lbs/100 gal	7	50	776
Check		-	57	773

* Significant at the 5% level

Table 13.-Disease index and yield of bean cv R-19 treated with various chemicals to control common bacterial blight

Treatment		Number of application	Disease index	Pounds per acre
Copper hydroxide	- 0.50 lb/100 gal	6	75	1,081.7
Copper hydroxide	- 1.00 lb/100 gal	6	58	1,323.0
Basic copper sulfate	- 1.00 lb/100 gal	6	33*	1,454.7
Basic copper sulfate	- 2.00 lbs/100 gal	6	58	1,389.1
Benomyl	- 0.25 lb/100 gal	3	70	1,403.4
Benomyl	- 0.50 lb/100 gal	3	58	1,246.8
Chlorothalonil	- 1.00 lb/100 gal	6	63	1,352.1
Chlorothalonil	- 2.00 lb/100 gal	6	63	1,454.7
Check		-	67	1,363.5

* Significant at the 5% level

Table 14.-Known or suspected phytoparasitic nematodes found in soil around the roots of different legumes at the Isabela Substation

Nematode	Legume Crop			
	Cowpea 1/	Red bean 2/	White bean 3/	Snap bean 4/
Rotylenchulus reniformis	x	x	x	x
Helicotylenchus spp.	x	x	x	x
H. dihyestera	x	x		
H. tropicus		x		
H. curvatus		x		
Meloidogyne	x	x		
Pratylenchus		x	x	x
P. coffeae		x		
Tylenchorhynchus sp.				x
Tylenchus	x	x	x	x
Aphelenchoides	x	x	x	x
Aphelenchus	x	x	x	x

1/ Cv Early Ramshorn
2/ Cv R-19
3/ Cv Bonita
4/ Cv Bountiful

harbored 11 of the 12 plant-parasitic nematodes found. The white bean and snap bean harbored 6 and 7 plant-parasitic nematodes, respectively. The cowpea variety examined harbored also 7 of the plant-parasitic nematodes identified.

Table 15 presents the nematodes associated with 28 accessions of cowpea planted at the MITA farm at Isabela. Seven genera of known or suspected plant-parasites were encountered. The nematodes associated with the majority of the accessions were Tylenchus, Aphelenchus and Aphelenchoides. The parasitic habits of species within this genera are still questionable. On the other hand, truly parasitic nematodes (Rotylenchulus, Helicotylenchus, Meloidogyne and Pratylenchus) were found associated with less than half of the accessions.

Evidently, additional information is needed to make final conclusions as to the resistance or susceptibility of these varieties or accessions to the nematodes encountered.

Table 16 summarizes the number or root-knot larvae present in the soil and roots of 11 bean accessions tested for resistance to M. incognita. As shown in the table, accessions 10R-58 and 4R-136 were found to harbor the least number of larvae in the roots and soil. This finding indicates that there is some source of resistance within these accessions. On the other hand, accessions 15R-66, 71-1R-113 and 15R-148 were found to harbor comparatively high numbers of root-knot larvae, indicating, to a certain extent, their susceptibility to M. incognita.

The number of nematodes present in the soil and root samples processed were relatively low, due mainly, to the short period of time (30 days) to which plants were exposed to the nematodes.

Table 15.-Known or suspected phytoparasitic nematodes associated with roots (R) and found in soil (S) around the roots of different accessions of cowpea planted in the farm of the Mayaguez Institute of Tropical Agriculture at Isabela

Accession	R[1/]	H	M	P	T	A	Ap
EN 56						R	SR
EN 99				R	S	R	SR
EN 73			R		R	SR	R
10R 61					R	R	SR
10R 65	S			S	S	SR	S
EN 69	S				S		S
EN 50	S	S			SR	SR	SR
EN 63	S	R			R	R	SR
EN 91	S		S	S	R	R	SR
EN 85					SR	R	
EN 46					S	R	S
EN 69					S		
EN 20R	S	S			R	S	
EN 43		R			R		R
EN 96		R	R	R	S	R	R
EN 21	S	S	S		SR		
EN 11			R		R		
EN 51			R		R		SR
EN 16					SR	R	
EN 1		R	S				
EN 60				R		R	
EN 9		R			S		
EN 36					SR	R	
EN 29	R			SR	S		R
EN 101	S	R	R		SR	R	SR
EN 77		R			R	R	S
EN 24		R			R	R	SR
EN 67		R		R	SR	R	SR

1/ R = Rotylenchulus, H = Helicotylenchus, M = Meloidogyne, P = Pratylenchus, T = Tylenchus, A = Aphelenchoides, Ap = Aphelenchus.

Table 16.-Average number of Meloidogyne incognita larvae in the roots and in soil around the roots of 11 bean accessions[1]

Accesssion	Average no. of nematodes from 50 pots/accession Soil	Roots
15R-42	2.1	9.0
15R-52	1.2	4.8
15R-57	1.7	6.5
10R-58	0.2	1.8
71-1R-63	3.1	8.7
15R-66	7.7	11.5
71-1R-70[2]	5.1	9.5
71-1R-101	4.1	5.3
71-1R-113	6.8	10.6
4R-136	0.8	1.4
15R-148	2.4	11.6

1/ Soil samples consisted in 250 cc of soil and root samples of the entire root system. Samples were taken 30 days after inoculation with the nematode.
2/ This accession was substituted for the variety Alabama Pole due to its low germination percentage.

Table 17.-Average number of Meloidogyne incognita larvae in the roots and in soil around the roots of 5 cowpea accessions[1]

Accession	Average no. of nematodes from 20 pots/accession Soil	Roots
10R-3	8.6	32.6
4R-9	6.3	19.6
4R-14	6.8	30.8
4R-22	7.4	42.9
4R-28	6.3	24.5

1/ Soil samples consisted in 100 cc of soil and root samples of the entire root system. Samples were taken 35 days after inoculation with the nematode.

Table 17 summarizes the number of root-knot larvae present in soil and roots of 5 cowpea accessions. As shown in the table, there seems to be very little difference in the number of nematodes harbored by the different cowpea accessions. The data suggests that accessions 4R-9 and 4R-28 may have some slight degree of resistance to the root-knot nematode.

The number of nematodes recovered in this test were also low. due mainly, to the short period of time (35 days) to which the plants were exposed to the nematodes.

The above findings are completely preliminary and conclusions cannot be drawn until more information is gathered.

D. Insect Control

a. Insecticide Trials

1. Cowpeas and Beans

Insect populations in the first plantings were very low. Leaf miners, bean beetles, aphids, leaf hoppers, pod-borers and the cowpea weevil appeared sporadically on cowpeas. At treatment time 36% of the first two leaves were infested and 30% of the plants had aphids. A similar picture was observed on beans. At treatment time leafhopper and leafminer populations were very erratic.

Harvest data for both legumes is presented in Table 18. Differences among treatments were not appreciable, though statistically significant in some cases.

2. Control of Chalcodermus ebeninus on Cowpeas

Insecticide trials were performed to control the cowpea weevil, Chalcodermus ebeninus which is considered the most serious insect pest of cowpea.

Table 18.-Mean yield per plot (120 ft^2) of bean cv Bonita 1, and cowpea cv Gold Coast treated with insecticides, Isabela Substation, January 1974

Treatment		Yield (pounds/plot) Cowpea	Bean
Cygon 2.67E (dimethoate)	- 0.5 pt/acre	3.3 a[2/]	3.7
Cygon 2.67E	- 1.0 pt/acre	2.9 ab	3.1
Diazinon AG-500 (diazinon)	- 0.5 pt/acre	3.3 a	3.7
Diazinon AG-500	- 1.0 pt/acre	2.4 b	3.1
Guthion 2E (azinphosmethyl)	- 1.0 pt/acre	3.2 ab	3.3
Guthion 2E	- 2.0 pt/acre	2.8 ab	3.3
Parathion 15 WP	- 0.5 lb/acre	3.3 a	3.7
Parathion 15 WP	- 1.0 lb/acre	3.0 ab	3.9
Furadan[1/] (carbofuran)	- 20.0 lbs/acre	-	3.4
Di-syston	- 7.0 lbs/acre	-	3.3
Check		2.6 ab	3.7

1/ Furadan and Di-syston were used on bean only.

2/ Means followed by the same letter are not significantly different at the 5% level.

Infestation counts during June 5, 12 and 19, 1974 [illegible] in Table 19. On June 5, the heaviest infestation was on plots treated with Furadan. Apparently, Furadan treatment in some way made conditions favorable for this insect. On June 12, the number of punctures per sample was lower in all treatments than in the control. Lannate reduced significantly the number of infested pods. The number was still higher in Furadan treated plots. The number of perforations on the Lannate and Toxaphene plots was very low when compared with other treatments. On June 19, perforations per sample were similar in all treatments.

Mean yield/plot is presented in Table 20. These, and the above observations show that even when differences were not ample, the Toxaphene and Lannate treatments were significantly superior to other treatments and the check. It should be stressed that treatment time coincided with a heavy rain period and that the test will be repeated.

b. Resistance Trials

The yield and infestation per cent for the first group of cowpea cultivars evaluated for resistance to the cowpea weevil, Chalcodermus ebeninus, are included on Table 21. Cultivars Lentejas and Pequeño had the lowest infestation, and Zipper Cream the highest. Apparently there is some relation between seed size and infestation. Lentejas and Pequeño are small seeded cultivars.

Data on infestation by the pod-borer, Etiella zinckenella, is included also on Table 21. Different degrees of infestation were found, ranging from a low of 9% for Lentejas to a high 28% for Climax.

Table 19.-Infestation of cowpea weevil, *Chalcodermus ebeninus*, on cowpea cv Early Ramshorn treated with insecticides, Isabela Substation, June 1974

Treatment	Per cent infested pods			Mean punctures/sample			Mean perforations/sample		
	5 June	12 June	19 June	5 June	12 June	19 June	5 June	12 June	19 June
Toxaphene (toxaphene) - 2.0 pts/acre	3	32 ab[2/]	38	1.5	14.75	21.25	1.5	3.75 ac	5.75
Methoxychlor 50 WP (methoxychlor) - 2.0 lbs/acre	6	35 ab	32	5.0	25.50	14.00	4.0	7.00 ac	7.00
Thiodan 2E (endosulfan) - 2.0 pts/acre	8	29 ab	47	3.75	29.25	30.00	2.5	3.25 ac	6.50
Lannate 90S (methomyl) - 0.5 lb/acre	8	23 a	50	2.75	14.50	23.50	0.5	2.75 bc	8.50
Cygon 2.67E (dimethoate) - 1.0 pt/acre	4	32 ab	38	2.0	22.75	20.00	0.0	5.50 ac	6.00
Furadan 10G (carbofuran) - 20.0 lbs/acre	17	39 b	47	21.5	26.00	15.75	9.5	9.00 a	5.50
Check	4	38 b	41	1.0	37.50	31.00	0.8	2.75 bc	6.50

1/ Infestation count based on sample of 25 pods/plot.

2/ Means followed by the same letter are not significantly different at the 5% level.

Table 20.-Mean yield per plot (180 ft^2) of cowpea cv Early Ramshorn treated with insecticides for the control of the cowpea weevil, Chalcodermus ebeninus, Isabela Substation, June 1974

Treatment		Mean yield (pounds)/ plot[1/]
Toxaphene 60%	- 2.0 pts/acre	4.6 a
Methoxychlor 50 WP	- 2.0 lbs/acre	3.6 b
Thiodan 2E	- 2.0 pts/acre	3.9 ab
Lannate 90S	- 0.5 lb/acre	4.4 ab
Cygon 2.67E	- 1.0 pt/acre	3.5 b
Furadan 10G	- 20.0 lbs/acre	3.9 ab
Check		3.7 ab

1/ Means followed by the same letter are not significantly different at the 5% level.

Table 21.-Infestation percentages of the pod-borer, Etiella zinckenella and the cowpea weevil, Chalcodermus ebeninus and mean yield per plot (60 ft^2) of six cowpea cultivars Isabela Substation, January 1974

Cultivar	Per cent infested pods		Mean yield (pounds)/ plot
	Pod-borer	Weevil	
Lentejas	9	12	0.8
Zipper cream	20	70	0.7
Pequeño	14	24	0.7
Gordo	21	49	0.5
Sin Fibra	12	52	0.4
Climax	28	42	0.8

Populations of leaf feeding insects were low. Aphids and leafminer were observed in some plots. Cultivars Lentejas and Climax presented very low populations of both. Cultivars Sin Fibra and Pequeño had the heaviest infestation of leafminer and aphids. On Cultivar Gordo, only some aphids were recorded. The rest of the varieties were free of phytophagous insects.

The yields and index of infestation for the first group of bean cultivars tested for insect resistance are included in Table 22. Damage index of Cerotoma ranged from 1.3 to 2.6. These variations are not conclusive and further tests should be conducted. On the other hand, infestation indexes of Empoasca showed resistance to this insect in the selections of Bonita, a white bean cultivar, while a high susceptibility was observed in the rest of the color seeded cultivars. Cultivars Rayada, Jamaica, Marca Diablo and Pompadour were among the most seriously affected. Even when these are preliminary trials the evidence of resistance to Empoasca is clear.

Seed of various bean cultivars kept at room temperature for 3 months after harvest were heavily infested with the bean weevil, Acanthoscelides obtectus (Say). Based on 100 seeds per cultivar, the following information was obtained:

Cultivar	Per cent Infested Seeds	Holes/100 Seeds
Sin Fibra	37	68
Galana	50	145
Borinquen	64	194
Rayada	77	363
Jamaica	95	834
Marca Diablo	82	378

Table 22.-Index of infestation of the bean beetle, Cerotoma ruficornis and the leaf hopper, Empoasca fabae, and mean yield per plot (60 ft^2) of 15 bean cultivars, Isabela Substation, January 1974

Variety	Average index[1/] Cerotoma	Empoasca Dec. 4	Empoasca Dec. 12	Mean yield (pounds)/ plot
Bonita No. 1	2.3	0	0	3.9
Bonita No. 2	1.3	0	0	1.1
Bonita No. 3	2.3	0	0	0.7
Bonita No. 4	1.6	0	0	0.5
Bonita No. 5	2.6	0	0	0.6
Bonita No. 6	1.6	0	0	2.5
Bonita No. 7	1.0	0	0	0.8
Bonita No. 8	1.6	0	0	3.5
Sin Fibra	2.0	3.0	4.0	0.2
Rayada	2.3	4.0	4.0	0.5
Jamaica	1.3	4.5	5.0	0.2
Marca Diablo	2.0	4.5	5.0	0.2
Pompadour	1.6	3.0	4.0	0.5
Galana	2.3	3.5	3.5	0.7
Borinquen	2.0	3.3	2.0	0.3

1/ Index from 1 to 5; one is the least infested and 5 the heaviest.

Table 23.-Infestation of six cowpea cultivars by the cowpea weevil, Chalcodermus ebeninus, Isabela Substation, June 1974

Cultivar	Date	Per cent infested pods[1/]	Mean punctures/sample	Mean perforation/ sample	Per cent perforations
P.R.-V-70-4R18	6/3/74	27 a[2/]	51.5	22.2	39.8 bc
P.R.-V-70-4R38	6/10/74	33 ab	83.0	4.5	7.5 a
P.R.-V-70-4R138	6/10/74	19 a	8.2	3.5	44.0 b
P.R.-V-70-4R2	6/14/74	27 a	25.2	4.5	15.2 ac
P.R.-V-70-4R1	6/14/74	23 a	16.2	4.7	33.6 ab
P.R.-V-70-4R28	6/16/74	46 b	44.0	13.7	25.4 ab

1/ Based on 25 pods/plot.

2/ Means followed by the same letter are not significantly different at the 5% level.

Rayada, Jamaica and Marca Diablo had the heaviest infestation. As in other cases reported, these are strictly preliminary results.

The results of a second group of cowpea lines planted on April 1-4, 1974 are included on Tables 23, 24 and 25. Results were erratic and were not in agreement with preliminary observations made earlier in the course of development of the Project. This could be due to a non-random distribution of the insect populations and to the very low population density. However, based on the percentage of perforations (percent of punctures reaching the seed) P.R.-V-70-4R138 and P.R.-V-70-4R18, even when they showed very low pod infestation, were the cultivars most heavily damaged by the insects. It should be pointed out that cowpeas were not generally planted at the Isabela Substation prior to these experiments, and consequently populations of insects associated with this crop are not well established. Repeated tests should be conducted to obtain conclusive results.

Dry seeds observed for punctures of Chalcodermus and infestation with Callosobruchus chinensis showed that cv P.R.-V-70-4R138 is slightly more tolerant to Callosobruchus than the rest of the cultivars (Table 26). Results with Chalcodermus were similar to those of the previous tests with fresh pods. Differences in yields/plot were considerable among cultivars.

c. Studies on the Leafminer, Liriomyza sativae

Liriomyza sativae[1/] Blanchard (Diptera:Agromyzidae), known as the vegetable leafminer, is a serious threat to tropical and subtropical legume production. During the larval stages of development, this pest consumes

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1/ Liriomyza munda Frick (Diptera:Agromyzidae) has been determined to be a junior synonym of L. sativae Blanchard.

Table 24.-Infestation of six cowpea cultivars by the cowpea weevil, *Chalcodermus ebeninus*, Isabela Substation, June 19, 1974

Cultivar	Per cent infested pods[1/]	Mean punctures/sample	Mean perforation/sample
P.R.-V-70-4R2	17 ab[2/]	8.50	0.75 a
P.R.-V-70-4R18	18 ab	8.75	5.25 ab
P.R.-V-70-4R28	35 c	27.00	9.00 b
P.R.-V-70-4R38	18 ab	10.75	2.75 ab
P.R.-V-70-4R1	23 a	22.00	7.50 ab
P.R.-V-70-4R138	10 b	7.00	2.50 ab

1/ Based on 25 pods/plot.

2/ Means followed by the same letter are not significantly different at the 5% level.

Table 25.-Infestation of *Chalcodermus ebeninus* and *Callosobruchus chinensis*, and mean yield per plot of six cowpea cultivars, Isabela Substation, June 1974

Cultivar	Per cent infested seeds[1/]		Mean yield (pounds)/plot
	Chalcodermus	*Callosobruchus*	
P.R.-V-70-4R2	4.0	1.0	8.7
P.R.-V-70-4R18	4.2	1.7	2.2
P.R.-V-70-4R28	5.5	1.2	3.3
P.R.-V-70-4R38	0.5	1.5	5.8
P.R.-V-70-4R1	4.0	1.5	5.2
P.R.-V-70-4R138	1.2	0.2	2.6

1/ Based on a sample of 100 seeds per 180 ft^2 plot.

Table 26.-Infestation of Chalcodermus ebeninus and Callosobruchus chinensis on cowpea seeds treated with insecticides, Isabela Substation, June 1974

Treatment		Per cent infested seeds[1/]	
		Chalcodermus	Callosobruchus
Toxaphene 60%	- 2.0 pts/acre	1.7	5.5
Methoxychlor 50 WP	- 2.0 lbs/acre	4.0	4.2
Thiodan 2E	- 2.0 pts/acre	2.0	3.2
Lannate 90S	- 0.5 lb/acre	2.2	4.2
Cygon 2.67E	- 1.0 pt/acre	5.5	6.5
Furadan 10G	- 20.0 lbs/acre	2.0	5.0
Check		2.2	4.2

1/ A sample of 100 seeds from each plot was examined.

Table 27.-Total number of adult Liriomyza sativae collected, during a 2-month interval, at different daily sampling periods[1/]

Daily sampling period	Total number of adults collected		
	Males	Females	Sex ratio (Males/Females)
8:00 am	30	96	0.31
10:00 am	37	82	0.45
12:00 am	68	57	1.19
2:00 pm	49	67	0.73
4:00 pm	44	53	0.83

1/ Collection period was between 26 July and 26 September, 1974.

the photosynthetic tissue of the host plant. Severe infestations of L. sativae may reduce the amount of photosynthetic tissue to almost zero. This results in a dramatic reduction in yield or, in extreme cases, no yield at all. It is, therefore, imperative to study the biology of this species, in order that the most effective control approaches be determined.

Extreme fluctuations, in the population density of L. sativae, have been observed in a number of areas over a period of years. The possibility of natural control of the pest population, by parasites, is an area of potentially productive investigation. Such an approach precludes the disadvantages inherent in a purely chemical approach to pest control.

As a result of the investigations recently initiated, three additional parasites of L. sativae[2/] were found in Puerto Rico. These species have been identified[3/] as (Hymenoptera: Eulophidae): Zagrammosoma sp., Clostorcerus nr. cinctipennis, and nr. Derostenus. The two previously reported[4/] parasite species were Digliphus begini (Ashm.) and Achrysocharella sp., also Eulophids. The determination of the species comprising the parasite complex, is the first step in the evaluation of the degree of natural control being exerted upon L. sativae.

2/ Parasitized, immature L. sativae were excised from tomato var. Floradel leaves on July 15 and 18, 1974.

3/ Specific determination of parasite species was conducted by Dr. Gordon Gordh, U.S. National Museum, Washington, D.C.

4/ Pérez-Pérez, Rafael. 1973. Liriomyza munda Frick (Diptera: Agromyzidae) attacking beans and cucumbers in Puerto Rico. J. Agr. Univ. P.R. 57(4): 350.

A study of the diurnal periodicity (total abundance upon host plants) of adult L. sativae was conducted. No significant difference in the total number of L. sativae, present on plants of bean cultivars Bonita, Rosita, Criolla and Naranjito, was found between five sampling periods. Sampling periods lasted 15 minutes, during which time as many adults as possible were collected. The sex ratio (males/females) changed during the day (Table 27). The highest proportion of females was present at 8:00 A.M., while the highest proportion of males was present at 12:00 A.M. A statistical comparison between sampling periods revealed no significant change in the sex ratio between 12:00 A.M., 2:00 P.M. and 4:00 P.M. (Table 28). Based upon this data and personal observations, it may be concluded that mating occurs predominantly during the afternoon.

A correlation analysis between nine meteorological parameters and the total, daily number of adult L. sativae proved non-significant for all nine comparisons (Table 29).

An attempt to rear L. sativae on artificial diet had negative results. The diet was prepared as follows:

Ingredient	Quantity
Casein	108 grams
Wesson salt	36 grams
Sucrose	95 grams
Wheat germ	162 grams
Yam flakes	35 grams
Choline chloride (500 mg)	3.6 grams
Ascorbic acid (L)	14.4 grams
Vitamin solution[5/]	35 ml
Formalin (37%)	2 ml
Tegosept	5.4 grams
Agar	30 grams
Aureomycin (250 mg capsules)	6 capsules
Benylate (0.2%)	2 ml
Distilled H_2O	2800 ml

5/ Vitamin solution was prepared by mixing 353 grams of vitamin mixture for insects, Vanderzant modification (obtained from Nutritional Biochemicals Corporation), with 1000 ml of distilled water.

Table 28.-A comparison of the variation in sex ratio (male/female) of adult *Liriomyza sativae* at different daily sampling periods1/

Sampling periods compared	Statistical interpretation
8:00 am versus 12:00 am	Significant (1% level)
8:00 am versus 2:00 pm	Significant (1% level)
8:00 am versus 4:00 pm	Significant (1% level)
10:00 am versus 12:00 am	Significant (1% level)
All other possible paired comparisons	Insignificant

1/ Based on the number of adult *Liriomyza sativae* collected during the 26 July - 26 September 1974 sampling interval.

Table 29.-Correlation analysis between different meteorological parameters and total daily number of adult flies (*Liriomyza sativae*) collected on 4 bean cultivars

Meteorological parameters tested1/	Statistical interpretation
Maximum temperature	Insignificant
Minimum temperature	Insignificant
Mean $\left(\frac{\text{maximum + minimum}}{2}\right)$ temperature	Insignificant
Solar radiation	Insignificant
Rainfall	Insignificant
Mean relative humidity	Insignificant
Amount of evaporation	Insignificant
Wind movement:	
Daily	Insignificant
Daytime	Insignificant

1/ Meteorological data collected at the Agricultural Experiment Station grounds at Río Piedras.

A survey is presently being conducted, to determine the wild and cultivated, host plants of L. sativae. A new insect record, for Puerto Rico, Calycomyza malvae Burgess (Diptera:Agromyzidae), and a previously undescribed species of Agromyzid, Liriomyza nr. archiboldi, were reported[6/].

d. Insect Collections

Samples of insects present in the legume plots are collected and processed. Each sample is kept in 70% alcohol and is being separated in groups and counted. This type of collections should be continued as they provide an idea of the insect fauna in the present crop ecosystem.

E. Virulence Study of Xanthomonas Isolates

Previous inoculation studies indicated that Xanthomonas isolates from bacterial blight or stem canker diseased cowpeas (Vigna unguiculata) were virulent to both cowpeas and beans (Phaseolus vulgaris). However, isolates from bacterial blight diseased beans were either virulent on both species or only on P. vulgaris. Hence, it was suggested that isolates that are virulent on both species should be called X. vignicola (Xv)-type, and those that were only virulent to beans as X. phaseoli (Xp)-type.

The results of field and greenhouse screening for resistance to bacterial blight during the past five years have indicated that resistance to Xanthomonas was prevalent in cowpeas, while even tolerance to Xanthomonas was a rarity in beans. These results suggested that if cowpea cultivars with highly susceptible genotypes were located, they also could be

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6/ Specific determination of Agromyzid specimens was conducted by George C. Steyskal, U.S. National Museum, Washington, D.C. and Kenneth A. Spencer, Cornwall, England.

susceptible to the Xp-type strains. The consequences of a search for virulence in Xanthomonas and resistance in V. unguiculata and P. vulgaris should be the following four combinations of reactions between the two host species and the pathogenic strains of Xanthomonas:

Xanthomonas type	Host Response V. unguiculata	P. vulgaris
A	Res.	Res.
B	Res.	Susc.
C	Susc.	Res.
D	Susc.	Susc.

The location of Xanthomonas isolates having the above pathogenicity types would serve the purpose of studying the inheritance of resistance of the two host species to each of the pathogenic types.

Inoculation Trial with ATCC Type Culture

Twenty-five cowpea accessions and the standard cultivars Early Ramshorn (a black-eye pea) and La Vega were planted in five replications in the greenhouse. The standard inoculation procedures were used. The inocula consisted of American Type Cultures X. vignicola #11648, X. phaseoli #9563, X. phaseoli var. fuscans #13464 and the Puerto Rico culture Xv #113. Seeds were sown on 5/29/74, seedlings were inoculated on 6/10/74 and disease response was recorded on 6/19/74. Table 30 summarizes the results of the pathogenicity test. The response of cowpea accessions could be divided into: 1) resistant to the four cultures, 2) intermediate and mixed response, and 3) susceptible to all cultures. The partial and misleading conclusions derived from this test were that: if only cowpea

Table 30.-Pathogenicity test with *Xanthomonas* cultures

Host	Response to inoculation[1/]			
	Xv PR #113	ATCC *Xv* #11648	ATCC *Xp* #9563	ATCC *Xpf* #13464
P. vulgaris				
La Vega (check)	--	--	--	--
La Vega (inoculated)	S	S	S	S
V. unguiculata				
Early Ramshorn (Check)	--	--	--	--
Early Ramshorn (inoculated)	S	S	R	S
4-R9	R	R	R	R
4-R91	R	R	R	R
4-R95	R	R	R	R
4-R105	R	R	R	R
4-R445	R	R	R	R
4-R464	R	R	R	R
4-R14	MS	R	R	R
4-R22	R	R	R	R
4-R28	MS	MS	R	R
4-R38	MS	MS	MS	R
4-R404	S	S	S	R
4-R251	MS	MS	S	MS
4-R331	MS	MS	MS	S
4-R54	S	MS	MS	HS
4-R351	MS	MS	S	S
4-R393	S	S	MS	MS
4-R75	S	S	S	S
4-R324	S	S	S	S
4-R218	S	S	HS	S
4-R266	HS	S	S	S
4-R302	S	S	HS	S
4-R31	HS	S	HS	S
4-R28	HS	HS	S	S
4-R136	HS	S	HS	HS
4-R184	HS	S	HS	HS

1/ R = Resistant; MS = Moderately susceptible; S = Susceptible; HS = Highly susceptible.

accessions 4-R9 (and other of similar reaction) were used, then all four cultures would be considered as avirulent; if 4-R31 and others were used, then all four cultures would be typed as Xv; if Early Ramshorn were used, then only #9563 would be Xp, but #13464 would be typed with other two cultures as Xv; and if 4-R404 and 4-R38 were used, then only #13464 would be typed as Xp and the rest as Xv. Consequently, the assignment of species epithets to Xanthomonas isolates at this stage of the work does not seem advisable.

Cultural Characteristics of the Re-isolates

Re-isolation of Xanthomonas from cowpea and bean seedlings that were inoculated with Xpf type cultures yielded a high frequency of Xv or Xp types. In other words, when X. phaseoli var. fuscans was used as inoculum, the majority (84.6 percent) of the re-isolates lacked the capacity to produce pigment in agar media (Table 31). However, the change from pigmentless, Xp or Xv, to pigment forming, Xpf or Xvf, occurred only in about 1.3 percent. Culture P.R.#436 not only was the first fuscans type X. vignicola, but also produced a characteristic blackish pigment. The remaining two X. vignicola var. fuscans were re-isolated from cowpea seedlings inoculated with the X. phaseoli var. fuscans type culture form ATCC #11648. These two re-isolates produced light brown pigment on agar.

The low frequency of Xpf types among the re-isolates corresponds with the low frequency of Xpf types under natural conditions.

The lack of pigment production in the re-isolated cultures suggest that the ability to produce pigment is not a fixed characteristic of a Xanthomonas culture. Also, the non-pigment-producing types can mutate and acquire the capacity to produce pigment.

Table 31.-Change in strain characteristic in Xanthomonas, as affected by host-passage

Original type	Inoculated Host	Re-isolate Type	Re-isolate No.
Xv	Phaseolus or Vigna	Xv	25
Xp	Vigna	Xv	40
Xp	Vigna	Xvf	1
Xpf	Vigna	Xv	20
Xpf	Vigna	Xvf	2
Xpf	Phaseolus	Xp	4
Xp	Phaseolus	Xp	6
	Total		98

F. Beans - Disease Resistance, Yield and Adaptability Trials

a. Red Bean Trials

1. Disease Resistance of Locally-Grown Cultivars

Purpose, Materials and Methods

Dr. Marcial Rico-Ballester, Horticulturist, Lajas Substation, has selected several bean cultivars that have been grown for decades in Puerto Rico. These cultivars are highly adaptable to various climatic conditions of the Island and are preferred by consumers. During the past rainy season (May-July, 1974) it was decided to grow these cultivars under severe disease conditions and select the outstanding ones.

Cultivars.--The cultivars of Puerto Rican origin were: Naranjito, Rayada, Bonita, Galana, Borinquen and Colorada del País. Cultivars which were selected by Dr. Rico-Ballester, but were not of Puerto Rican origin were: Diablo, Jamaica, Pompadour, Nima de Colombia and French Horticultural. The cultivar Ecuador-299 was used as a standard because of its resistance to diseases. The 12 cultivars were planted in a randomized complete block design with four replications. Each replication consisted of a row 15 feet long and 24 inches wide. Rows were placed at a 44-inch distance from each other. One hundred seeds were sown per replicate, that included two rows with 50 seeds each placed 18 inches apart on the raised soil of the row.

Seeds were not treated with fungicides. No fungicides were applied during the trial. Insecticides were applied whenever the presence of a pest required it.

Overhead irrigation was set up in the plot. If no rainfall occurred within two consecutive days, the plot was irrigated to maintain the high level of moisture.

This trial was sown on May 9, 1974 and harvested between July 3 to July 23, 1974. Planting was done at the Las Gomez field, Mayaguez Institute of Tropical Agriculture, Mayaguez, Puerto Rico.

Results

Germination

Even though the soil was highly infested with soil-borne pathogens, especially Rhizoctonia and Sclerotium rolfsii, the overall germination was satisfactory. Six cultivars had 80% or more germination within a week (see Table 32). Perhaps a reason for the low germination of cultivar Ecuador-299 was that the seed was 18-month old.

Diseases

I. Southern Blight.--Southern blight, caused by Sclerotium rolfsii, usually attacks seedlings between emergence and 3 weeks of growth. Under the warm humid conditions of the Island the early infection causes the death of the seedlings.

Table 33 compares the number of seedlings germinated at 1 week, with the number of plants harvested. Cultivar Rayada was the only one that had 2.2% more plants at harvest. On the other extreme, 18.9% of the plants in the cultivar Colorada del País died before harvest. Besides Rayada, cultivars French Horticultural, Borinquen and Nima could be considered as field resistant.

Table 32.-Red and pinto bean Yield Trial No. 1 - Seed Germination

Cultivar	Rep-A	Rep-B	Rep-C	Rep-D	Total	Percent
Ecuador 299	56	42	55	59	212	53
Naranjito	64	61	89	47	261	65
Rayada	33	65	89	82	269	67
Jamaica	70	76	90	82	318	80
Bonita	80	78	80	85	323	81
Pompadour	80	90	88	75	333	83
Galana	73	84	87	83	327	82
Nima de Colombia	94	71	77	74	316	79
Diablo	87	82	66	78	313	78
Borinquen	75	61	49	80	265	66
Colorada del País	82	94	84	74	334	84
French Horticultura	96	82	89	89	356	89

Table 33.-Seedling mortality due to southern blight disease in Red Bean Trial No. 1

Cultivar	Number of plants		Percent Loss	Percent stand (for 400 seeds)
	Germinated 1/	Harvested 2/		
Ecuador 299	212	201	5.2	50.25
Naranjito	261	227	13.0	56.75
Rayada	269	275	+2.2	68.75
Jamaica	318	297	6.6	74.25
Bonita	323	288	10.8	72.00
Pompadour	333	299	10.2	74.75
Galana	327	296	9.5	74.00
Nima de Colombia	316	311	1.6	77.75
Diablo	313	298	4.8	74.50
Borinquen	265	260	1.9	65.00
Colorada del País	334	271	18.9	67.75
French Horticultural	356	353	0.8	88.25

1/ Counted one week after sowing.

2/ Counted 2 1/2 months after sowing.

Cultivars Diablo, Ecuador-299 and Jamaica could be designated as field tolerant, while cultivars Galana, Bonita, Pompadour, Naranjito and Colorada del País as susceptible.

II. Rhizoctonia Root Rot and Stem Canker.--Rhizoctonia solani infects the bean plants from seedling to mature stages. Infections occur at both below-grownd parts of the plants as well as in parts of the stem which may touch the ground. Some mortality occurs during the seedling stage, but the main effect of the disease is reduction in vigor and yield.

Disease Evaluation

A. Plants were graded for the size and frequency of lesions as: Slightly susceptible (SS) = superficial lesions less than 5 mm long at the below-ground or ground level of the stem; moderately susceptible (MS) = lesions about 10 mm long, brown color and slightly depressed, at below-ground or ground level on the stem; susceptible (S) = root system infected, lesions on stem and branches; highly susceptible (HS) = root system mostly rotted, adventitious roots maintain growth of the plant, many stem and branch lesions.

B. Cultivars were evaluated by their frequency of disease incidence. For example, MS 7/74 means that seven out of 74 plants in the replicate-D of the cultivar Galana had moderately susceptible response to Rhizoctonia root rot.

As the final column in Table 34 indicates, cultivar Ecuador-299 was almost free from infections. On the other hand, Colorada del País was 44% infected. Even though one-third of plants in cultivar Diablo were infected, the lesions were small and the disease was moderate. Only cultivars Rayada and Galana had low disease frequencies.

Table 34.-Disease incidence in Red Bean Trial No. 1

Cultivar	Rhizoctonia root rot and stem canker		Ashy stem blight	
	Ratio	Percent diseased plants	Ratio	Percent diseased plants
Ecuador 299	3/201	1.5	13/201	6.5
Naranjito	47/227	20.7	173/227	76.2
Rayada	40/275	14.5	205/275	75.0
Jamaica	55/297	18.5	227/297	76.5
Bonita	74/288	25.7	27/288	9.4
Pompadour	48/299	16.0	134/299	44.8
Galana	41/296	13.9	68/296	24.0
Nima de Colombia	48/311	16.0	27/311	8.6
Diablo	100/298	33.6	181/298	60.0
Borinquen	38/260	15.0	68/260	26.0
Colorada del País	119/271	44.0	6/271	2.2
French Horticultural	78/353	22.0	103/353	29.2

III. Ashy Stem Blight.--Ashy stem blight, caused by Macrophomina phaseoli, is a severe disease of beans both at seedling stage and at mature plant stages. The seed-borne disease begins at the cotyledonar node after seedling emergence. The infection spreads into the length of the seedling stem, followed by wilt and death of the seedlings. On the mature plant ashy stem blight occurs mostly after the flowering stage. Secondary infections occur at pedicular, peduncular and stem nodes. Disease spreads downward into the main stem. Usually one or two branches per plant are infected. Under high humidity, the infection spreads to pods and beans.

Table 34 shows the ratio of infected plants in each cultivar. Colorada del País was the least diseased, followed by Ecuador-299, Nima and Bonita. These four cultivars could be considered ashy stem blight resistant. There is a need for further screening and cleaning of these cultivars from the susceptible off-types or segregants. Cultivars Galana, Borinquen, French Horticultural and Pompadour were susceptible, while Naranjito, Rayada and Jamaica were highly susceptible.

IV. Bacterial Blight and Stem Canker.--Strains of Xanthomonas cause leaf blight and stem canker of beans under the moist and warm climatic conditions of the Island. The source of primary infection could be seed-borne, soil-borne, carried by wild legumes, or blown-in by wind. Leaf blight symptoms are more common on beans than stem canker symptoms. However, under hot and humid weather many bean cultivars develop stem canker lesions in the field.

Disease Evaluation

The size of the lesions, the frequency of infection, the presence of stem canker, and the earliness (in relation to pod set) at which a cultivar was diseased were used as criteria for grading susceptibility. The grades were: slightly susceptible (SS) = small lesions on leaves of mature green-pod bearing plants; moderately susceptible (MS) = leaf lesions 10 to 15 mm in size, few, on mature plants; susceptible (S) = leaf lesions 10 mm and larger, many, moderate chlorosis of older leaves; highly susceptible (HS) = large lesions, chlorosis of older leaves, defoliation, stem canker, infection occurs before flowering.

The data on disease incidence in this test is summarized in Table 35. No bacterial blight lesions were observed on leaves of cultivar Bonita throughout this trial. Cultivars Nima and French Horticultural were graded as field tolerant. Cultivars Pompadour and Rayada were designated as moderately susceptible. Cultivar Ecuador-299, which is sensitive to day-length and continues to grow without flowering when planted in mid-May, was graded as susceptible. Mostly the older leaves, some 2-month old, were diseased. All other cultivars in the trial were graded as highly susceptible. Cultivars Jamaica and Colorada del País were defoliated by the time their pods turned color.

V. Rust.--The summer rainy season is not an optimum period for rust (Uromyces appendiculatus) development in the field. However, the cool dry season of December to April provides the right conditions for severe rust attack in the field. The yield trial conducted by Dr. Rico-Ballester at the Lajas Substation was graded for rust during March, 1974. All

Table 35.-Summary of bacterial blight[1/] incidence in the Red Bean Yield Trial No. 1

Variety No.	Cultivar	Response Rep. A	Rep. B	Rep. C	Rep. D	Average Response
C-III-1	Ecuador 299	S	S	--	S	S
-2	Naranjito	HS	--	--	HS	HS
-3	Rayada	MS	--	--	MS	MS
-4	Jamaica	HS	HS	HS	HS	HS
-5	Bonita	--	--	--	--	--
-6	Pompadour	S	--	--	MS	MS
-7	Galana	HS	HS	--	HS	HS
-8	Nima de Colombia	MS	SS	--	MS	MS
-9	Diablo	HS	HS	--	HS	HS
-10	Borinquen	HS	HS	--	HS	HS
-11	Col. del Pais	HS	HS	HS	HS	HS
-12	Fr. Horticultural	MS	--	--	MS	MS

1/ *Xanthomonas* strains.
Selections for bacterial blight resistance: Bonita, Nima de Colombia, French Horticultural

Date Planted: 5/9/74
Date Recorded: 7/11/74

cultivars in this test were susceptible to rust (Table 36). Cultivar Diablo was the most severely infected. Ecuador-299 was free from rust.

VI. Common Bean Mosaic Virus.--Natural field infection of CBMV occurred in the Lajas yield trial. The following cultivars were graded as susceptible: Colorada del País, Naranjito, Diablo, Galana, Bonita, French Horticultural, Nima and Borinquen. Cultivar Ecuador-299 is CBMV resistant (Table 36). Not a single case of CBMV was recorded in the Mayaguez plot.

VII. Whitefly Transmitted Viruses.--Both golden yellow mosaic (GYM) and Rhynchosia mosaic (RM) were present in the plot in low levels. The ratio of GYM and/or RM infected plants to non-infected in each cultivar was: Ecuador-299, 0/201; Naranjito, 3/227; Rayada, 5/275; Jamaica, 8/297; Bonita, 4/288; Pompadour, 7/299; Galana, 2/296; Nima, 7/311; Diablo, 11/298; Borinquen, 5/260; Colorada del País, 9/271; and French Horticultural, 7/353. The frequency of the whitefly transmitted virus diseases for the total plot was 2.0%.

Adaptability

Stand.--Cultivar French Horticultural had the best stand throughout the trial (Table 33). Cultivars Jamaica, Galana, Nima and Diablo maintained a good stand of between 74 to 77 percent of the seeds sown. Cultivars Naranjito, Rayada, Bonita, Pompadour, Borinquen and Colorada del País had a fair stand (between 63 to 72 percent) of the seeds sown. Ecuador-299 had the poorest stand (50 percent) (Table 33).

Table 36.-Summary of field responses[1/] of bean cultivars to diseases during the spring and summer of 1974 (Red Bean Yield Trial No. 1)

Cultivar	CBMV (1)	Bacterial blight (2)	Southern blight (3)	Rhizoctonia root rot (4)	Ashy stem blight (5)	Rust[2/] (6)	Selection for disease resistance
Ecuador 299	R	S	MS	R	R	0	1, 4, 5, and 6
Naranjito	S	HS	MS	S	HS	5	---
Rayada	R	MS	R	S	HS	5	1 and 3
Jamaica	R	HS	MS	S	HS	5	1
Bonita	S	R	S	S	R	5	2 and 5
Pompadour	R	MS	S	S	S	5	1
Galana	S	HS	S	MS	S	4	4
Nima	S	FT	R	S	R	5	2, 3, and 5
Diablo	S	HS	MS	MS	HS	5	4
Borinquen	S	HS	R	S	S	5	3
Colorada del Pais	S	HS	HS	HS	R	5	5
Fr. Horticultural	S	FT	R	S	S	5	2 and 3

1/ Response: R = resistant; FT = field tolerant; MS = moderately susceptible; S = Susceptible; HS = Highly susceptible.

2/ Rust response: 0 = immune to 5 = highly susceptible.

Overall Field Performance.--Plants of Ecuador-299 had the best disease-free appearance, and were followed by those of Nima, Bonita and French Horticultural, in descending order (Tables 36 and 37). Table 37 shows the ratio of disease-free with total plants in the field. Cultivars Diablo, Naranjito, Jamaica and Rayada had severe ashy stem blight incidence. The infected stems of these cultivars gave a grayish cast to the row of plants as pods began to mature. Both Rhizoctonia root rot and ashy stem blight affected the healthy appearance of Pompadour plants. Bacterial blight and Rhizoctonia root rot affected the appearance of cultivar Borinquen. Plants of cultivar French Horticultural were moderately affected with ashy stem blight and Rhizoctonia root rot. In spite of these diseases this cultivar appeared generally healthy. The absence of bacterial blight on leaves of Bonita, rendered a green and fresh texture to the cultivar. The main disease of cultivar Bonita was Rhizoctonia root rot. Severe bacterial blight disease and moderate incidence of ashy stem blight affected the healthy appearance of cultivar Galana as its pods began to mature. Cultivar Colorada del País was rather remarkable in that in spite of its high degree of susceptibility to bacterial blight it had a high percentage of "healthy" plants which yielded well. The diseased plants were affected with Rhizoctonia root rot.

Response to Day-Length.--Plants of cultivar Ecuador-299 grew vegetatively throughout the trial without flowering. Plants of the cultivar Nima grew vigorously but flowered late. Less than one-half of the plants set pods. Those that set pods had only one to two pods per plant. Most

Table 37.-Overall ratio of healthy[1/] plants (Red Bean Trial No. 1) after 2 1/2 months of growth in the field during the wet season[2/]

Cultivar	Ratio of healthy plants to total stand per replicate					Percent Healthy
	Rep. A	Rep. B	Rep. C	Rep. D	Total	
Ecuador 299	46/49	36/40	58/62	53/50	193/201	96.0
Naranjito	0/64	9/56	0/60	11/47	20/227	8.8
Rayada	11/45	11/88	4/81	13/61	39/275	14.2
Jamaica	2/66	5/69	12/79	0/83	19/297	6.4
Bonita	45/72	48/68	49/68	51/80	193/288	67.0
Pompadour	38/80	43/80	33/77	4/62	118/299	41.0
Galana	40/58	50/80	43/84	55/74	188/296	63.5
Nima de Colombia	78/89	50/70	61/78	52/74	241/311	77.5
Diablo	1/89	4/68	2/68	5/73	12/298	4.0
Borinquen	41/61	11/84	0/52	0/67	52/271	19.2
Colorada del Pais	55/55	54/83	64/64	31/69	204/271	75.3
Fr. Horticultural	51/84	54/79	34/91	39/99	178/353	50.4

1/ Absence of Rhizoctonia root rot and stem canker, ashy stem blight, golden yellow and Rhynchosia mosaic diseases.

2/ Recorded 7/11/74.

of the pods were either empty or contained one or two beans. Only a few plants in each replicate yielded normally and were selected as day-length insensitive.

Habit.--Cultivars French Horticultural and Ecuador-299 had vine habi Ecuador-299 had indeterminate growth, while French Horticultural stopped vegetative growth after pods turned color. Cultivar Galana had a determinate low vine habit and cultivar Bonita was a semi-vine of intermediate height. The remaining cultivars all had bush habit. Cultivar Nima had a tall bush growth.

Grading of Seed After Threshing

The severe disease conditions under which plants in this trial grew resulted in a great deal of seed damage due to fungus and bacterial infections. A number of diseased seeds were cultured on Nutrient Agar for identification of the causal organisms. Most of the bacterial lesions were caused by Xanthomonas. The fungus lesions contained a number of species which will be identified later.

Table 38 shows the summary of disease, pest and mechanical damage. The grading was done after pods were threshed. A large number of seeds from cultivars Pompadour and Rayada had the yellow bacterial lesions. However, both cultivars were moderately susceptible to leaf blight caused by the pathogen. Cultivars Jamaica and Borinquen had high seed infections. The rest of the cultivars had a low incidence of bacterial lesions. The incidence of fungal infection was highest in seeds of cultivars Jamaica, Naranjito and Borinquen. Other cultivars had a moderate incidence of fungal infection, except those of French Horticultural which had the lowest incidence.

Table 38.-Uncleaned seed from Red Bean Trial No. 1 graded for disease, insect, and mechanical damage after threshing (July 1974)

Cultivar	Grade Index1/ for seed damage: Bacterial lesion	Fungus growth	Weevil2/ infestation	Broken or split	Recommendation for wet season planting
Naranjito	3	7	4	3	Not recommended
Rayada	7	3	1	3	" "
Jamaica	5	8	1	2	" "
Bonita	3	4	1	1	Acceptable candidate
Pompadour	8	3	1	2	Not recommended
Galana	3	4	1	1	Acceptable candidate
Diablo	3	4	1	1	" " 3/
Borinquen	6	7	2	1	Not recommended
Colorada del P	3	4	2	3	Acceptable candidate
Fr. Horticultural	3	2	2	1	Recommended

1/ Index: 1 = no damage to 10= all seeds damaged.
2/ Chalcodermus ebeninus.
3/ Not recommended due to susceptibiiity to diseases

Cowpea pod weevil (Chalcodermus ebeninus) caused some damage to the seeds. During the rainy season introduces Xanthomonas into damaged seed coats of infested beans.

Each cultivar was recommended for planting during the wet season on the basis of the frequency of pathogens associated with the seeds and their general appearance. Seeds of cultivar French Horticultural were the least diseased and damaged. The variety was recommended for wet season cultivation. Cultivars Bonita and Galana were acceptable candidates for recommendation for cultivation during the rainy period. Cultivar Diablo, though it had relatively clean seed, is not recommended as a candidate for wet season planting due to its overall disease susceptibility. The remainder were rejected for rainy season cultivation.

Yield

The Yield Trial No. 1 was centrally located in a plot with relatively uniform soil. The plants were fertilized with 300 pounds of a 5-10-10 formulation per acre. Weeding was done mechanically. The absence of pod set on Ecuador-299 and Nima resulted in missing data from eight plots within the layout of the randomized complete block design. The complete yield data is presented in Table 39.

Cultivars French Horticultural, Colorada del País and Bonita had the highest yields. Cultivars Pompadour, Galana and Borinquen followe the first group in productivity. Cultivar Diablo was intermediate in its yielding quality, while Jamaica, Rayada and Naranjito had the lowest yields.

Table 39.-Yield of red and pinto beans cultivated at Mayaguez during the wet season (5/9 to 7/23/74)

Variety	Weight of beans (grams) per replication				Total weight (grams)	Average weight/ replicate	Total weight/ plant (grams)	Kilograms per hectare
	A	B	C	D				
1. Ecuador 299[1/]	---	---	---	---	---	---	---	---
2. Naranjito	125.20	299.40	262.45	168.16	855.21	213.8	3.38	27.6
3. Rayada	251.95	279.15	214.35	160.05	905.50	226.37	3.29	54.5
4. Jamaica	192.14	282.60	207.50	263.80	946.04	236.51	3.21	34.3
5. Bonita	306.93	381.15	301.65	333.45	1323.18	330.80	4.59	71.0
6. Pompadour	266.90	375.15	313.53	182.70	1138.28	284.57	5.20	35.4
7. Galana	133.10	382.51	381.63	238.55	1135.79	283.95	3.84	33.5
8. Nima[2/]	---	---	---	---	---	---	---	--
9. Diablo	257.98	324.40	221.85	219.85	1034.08	258.52	3.47	58.9
10. Boriquen	307.40	132.05	269.30	388.15	1096.9	274.22	4.22	05.0
11. Col. del País	321.25	317.20	383.93	307.54	1329.92	332.48	4.91	76.0
12. Fr. Horticultural	530.93	401.68	360.60	272.10	1565.31	389.08	4.43	42.0

1/ Day-length sensitive; no flowering; only vegetative growth.

2/ Day-length sensitive; late flowering; very limited pod set.

Cultivar Pompadour had the highest yield per plant, which was followed by Colorada del País and Bonita. Both French Horticultural and Borinquen also had good yields per plant. However, Galana, Diablo, Naranjito, Rayada and Jamaica had low yields per plant.

Yield Comparison Between Lajas and Mayaguez and Cultivar Recommendations

Table 40 compares the yield (kilograms per hectare) of the dry beans harvested by Dr. Rico-Ballester in the Lajas yield trial with those obtained in the trial at Mayaguez. The main factors affecting the yields in these two trials were time of planting and disease control

Some day-length sensitive cultivars like Nima responded drastically to the slight increase in the day-length while others had a much less severe reaction. Both French Horticultural and Galana had slightly longer vines than was observed in the March planting at Lajas. In general there was very little difference in the habit of other cultivars.

The Lajas trial was treated with pesticides. The only major disease at Lajas was rust, while the Mayaguez trial was free of rust. At Mayaguez no pesticides were applied. The soil in the Mayaguez plot was heavily infested with soil-borne pathogens. At Lajas, even though there were soil-borne diseases, these were not as prevalent as in Mayaguez.

The warm weather in June at Mayaguez may have had some effect on pollen viability. However, Lajas is generally slightly warmer than Mayaguez. A significant difference was the high humidity of May-July which enhanced disease incidence in the Mayaguez plot.

Table 40.-Comparison of yield between winter planting with disease control at Lajas and spring planting without disease control at Mayaguez

Cultivar	Yield (Kilograms/hectare)		Percent yield difference
	Lajas 2/20/74 1/	Mayaguez 5/9/74 1/	
Naranjito	1,652.0	627.6	62
Rayada	1,159.0	664.5	43
Jamaica	1,285.0	694.3	46
Bonita	1,708.0	971.0	43
Pompadour	1,734.0	835.4	52
Galana	1,614.0	833.5	48
Nima	1,439.0	No yield	100
Diablo	814.0	758.9	7
Borinquen	1,390.0	805.0	42
Colorada del País	1,406.0	976.0	31
Fr. Horticultural	1,114.0	1,142.0	+3
Overall average			47.1

1/ Planting dates.

Comparison of Cultivar Yields.--Yield of cultivar Diablo was low at Lajas. The main reason for this low yield was severe rust infection. The main reason for the low yield at Mayaguez was its susceptibility to ashy stem blight. However, seeds of this cultivar were relatively free from diseases. The low yields of this cultivar at both trials indicated that it was not well adapted to the lowland tropical conditions.

French Horticultural yielded almost exactly the same amount of seed in both trials. Perhaps the slight increase in the growth period, due to longer day-length, caused increase in pod set and hence made up for disease losses. It is interesting that in the Lajas trial French Horticultural had one of the lowest yields, while in Mayaguez it had the highest yield. The seeds of this cultivar were the least affected by diseases (Table 38). French Horticultural is recommended for Spring cultivation in the lowland tropics. However, it is necessary to secure CBMV-free seeds of this cultivar.

Cultivar Bonita yielded well in both trials. It is highly adapted to humid tropical conditions. If CBMV and rust resistance are incorporated into this cultivar it could become and exceptional tropical bean. Common bean mosaic virus-free seeds of Bonita should be planted on well drained sandy clay loam soils. Bonita is suggested as a recommended cultivar for wet season cultivation.

Colorada del País had intermediate yield at Lajas, but yielded relatively well at Mayaguez. This cultivar is highly adaptable to wet tropical conditions. It sets pods in spite of its high susceptibility to bacterial blight and its seeds have a low index of disease incidence.

This cultivar merits further studies. Its high yield quality, under warm and wet conditions, should be analyzed in greater detail. Further tests will be carried to ascertain its resistance to ashy stem blight. Resistance to CBMV, bacterial blight, rust and Rhizoctonia root rot should be incorporated into this cultivar.

If ashy stem blight resistance is incorporated into Pompadour, it could become a good wet season bean for the tropics. It yielded well at Lajas, and despite the 52% loss of yield in the Spring planting, it still produced above average for the period. Pompadour was only moderately susceptible to bacterial blight, which makes it an important candidate for cultivation in the moist tropical lowlands.

Galana yielded well in both trials. The main reason for its relatively high yield in Mayaguez was its intermediate susceptibility to ashy stem blight and Rhizoctonia root rot. The seeds of Galana had a low index of disease incidence. Common bean mosaic virus-free seed of this cultivar is recommended for cultivation from mid-November to mid-May. If CBMV and rust resistance are incorporated into this cultivar it could become an exceptional tropical dry bean.

Cultivars Naranjito, Rayada, Jamaica and Borinquen are not recommended for cultivation during the wet season.

The average loss of yield due to the combined efeect of (1) diseases and (2) planting during the long day-length period was 47.1 percent (Table 40). These data suggest that unless a farmer has a cultivar such as French Horticultural, he may expect about 50% yield loss if he plants in the Spring as compared to yields he may realize in mid-Fall and early Winter plantings.

2. Adaptability, Yield and Disease Resistance Trial with Cultivars and Advanced Lines (Yield Trial No.2)

Purpose, Materials and Methods

Several red bean cultivars have proved highly adaptable to lowland tropical conditions in various locations. In this trial three recent releases from the United States and nine tropical cultivars were grown together for the purpose of comparing their relative response to diseases, and hence yielding capacity.

Cultivars.--Cultivars Ecuador-299, Mexico-235 and 27R were selected from among the red beans in the Central American Cooperative Progra for the Improvement of Edible Crops (PCCMCA). Cultivar Ecuador-299 was used as "disease resistant standard". Galana is a Puerto Rican cultiva which was used as the "local standard". Santa Ana is a high yielding early bush type from Nicaragua. Entries K-2-1-2, H-2-4 and I-2-2-2 are selections from the cultivar Pompadour from the Dominican Republic. Cu tivars Royal Red Kidney, Big Bend Red Mexican, Colombia Pinto and Apoll are USDA releases.

Seeds were not treated with fungicides. No fungicides were applie during the trial. Insecticides were applied whenever the presence of a pest required it.

Overhead irrigation was set up in the plot. If no rainfall occurr within two consecutive days, the plot was irrigated to maintain the hig level of moisture.

This trial was sown May 9, 1974 and harvested between July 1 to 23, 1974. Planting was done at the Las Gomez field, Mayaguez Institute of Tropical Agriculture (MITA), Mayaguez, Puerto Rico. This field is high infested with soil-borne pathogens.

The 12 cultivars were planted in a randomized complete block design with four replications. Each replication consisted of a row 15 ft long and 24 inches wide. Rows were placed at a distance of 44 inches from each other. One hundred seeds were sown per replicate, in two rows with 50 seeds each placed 18 inches apart on the raised soil of the row.

Results

Germination

Even though the soil was highly infested with soil-borne pathogens, especially *Rhizoctonia solani* and *Sclerotium rolfsii*, the overall germination was at an acceptable level. Cultivar Mexico-235 was the only one with over 75% germination. The rest, except cultivar Santa Ana, had a germination percentage of between 55 to 65 (Table 41).

Diseases

I. Southern Blight.--Only Santa Ana seedlings appeared highly susceptible to southern blight (*Sclerotium rolfsii*). Cultivar 27-R is also susceptible to this disease. Southern blight was mostly responsible for the death of all plants in two replicates of 27-R and in one replicate of Santa Ana (Table 43). Most plants in these replicates were dead before pods matured.

II. Rhizoctonia Root Rot and Stem Canker.--*Rhizoctonia solani* infects the bean plants from seedling to mature stages. Infections occur at both below ground parts of the plants as well as at various parts of the stem which may touch the ground. Some mortality occurs during the seedling stage, but the main effect of the disease is reduction in vigor and yield.

Table 41.-Seedling stand data from the Red Bean Yield Trial No. 2, recorded 20 days after sowing of seeds

Cultivar	Surviving plants					
	Rep. A	Rep. B	Rep. C	Rep. D	Total	Percent
Ecuador 299	40	56	60	64	220	55.0
Galana	84	69	58	48	259	65.0
Royal Red Kidney	66	42	32	73	213	53.0
Big Bend Red Mexi	57	54	72	69	252	63.0
Colombia Pinto	68	47	53	70	238	59.0
Apollo	44	55	67	48	209	52.0
Mexico 235	74	78	74	84	310	77.5
Santa Ana	24	31	15	36	106	26.5
Pompadour K-2-1-2	60	72	74	72	278	69.5
Pompadour H-2-4	59	58	62	48	227	57.0
Pompadour I-222	13	42	33	63	211	53.0
27R	12	48	76	47	243	61.0

Disease Evaluation

Plants were graded for the size and frequency of lesions as: Slightly susceptible (SS) = superficial lesions less than 5 mm long at the below ground or ground level of the stem; moderately susceptible (MS) = lesion about 10 mm long, brown color and slightly depressed, at below ground or ground level on the stem; susceptible (S) = root system infected, lesions on stem and branches; highly susceptible (HS) = root system mostly rotted, adventitious roots maintain growth of the plant, many stem and branch lesions.

Cultivars Ecuador-299 and Mexico-235 were free from Rhizoctonia disease symptoms during this trial. Both Galana and Pompadour (I-2-2-2) seemed to possess a certain amount of field tolerance. Cultivars Royal Red Kidney, Colombia Pinto, Santa Ana and 27-R were highly susceptible.

III. Ashy Stem Blight.--Ashy stem blight caused by Macrophomina phaseoli is a severe disease of beans both at seedling and at mature plant stages. The seed-borne disease begins at the cotyledonar node after seedling emergence. The infection spreads into the length of the seedling stem, followed by wilt and death of the seedlings. On the mature plant ashy stem blight occurs mostly after the flowering stage. Secondary infections occur at pedicular, peduncular and stem nodes. Disease spreads downward into the main stem. Usually one or two branches per plant are infected. Under high humidity, the infection spreads to pods and seeds. In grading bean response to ashy stem blight, plants with one or two diseased branches were graded as susceptible (S) and plants with the majority of branches infected as highly susceptible (HS).

Cultivars Ecuador-299, Mexico-235, Pompadour I-2-2-2 and 27-R were free from ashy stem blight disease. Cultivars Pompadour H-2-4 and Apollo could be considered moderately susceptible.

IV. Bacterial Blight and Stem Canker.--Strains of Xanthomonas cause leaf blight and stem canker of beans under the moist and warm climatic conditions of the Island. The source of primary infection could be seed-borne, soil-borne, carried by wild legumes, or blown-in by wind. Leaf blight symptoms are more common on beans than stem canker symptoms. However, under hot and humid conditions many bean cultivars develop stem canker lesions in the field.

Disease Evaluation

The size of the lesions, the frequency of infection, the presence of stem canker, and the earliness (in relation to pod set) at which a cultivar was diseased were used as criteria for grading susceptibility. These were: Slightly susceptible (SS) = small lesions on leaves of mature green-pod bearing plants; moderately susceptible (MS) = leaf lesions 10 to 15 mm in size, few, on mature plants; susceptible (S) = leaf lesions 10 mm and larger, many, moderate chlorosis of older leaves; highly susceptible (HS) = large lesions, chlorosis of older leaves, defoliation, stem canker, disease becomes severe before flowering. All cultivars were susceptible to bacterial blight disease.

V. Rust.--The summer rainy season is not an optimum period for rust (Uromyces appendiculatus) spread in a bean field. Due to the prolonged presence of a moisture film on the leaves several bacterial species (including Xanthomonas spp.) enter the rust through the ruptured epidermis

and cause the death of the host tissue within and around the rust lesion. Also, a hyperparasite of the genus Darluca attacks the healthy rust spores and mycelia causing further reduction of rust propagules.

Evaluation of the rust reaction of the cultivars included grading of pustule size and intensity of rust incidence. In grading the pustule size, "0" indicates no infection, while "5" indicates a pustule of 500 microns diameter or larger. The intensity is presented in percentage from "0" to "99".

VI. Whitefly Transmitted Viruses.--The whitefly population is generally quite low during the summer rainy season. One factor in reducing the whitefly population during the prolonged period of high humidity appears to be fungal pathogens that parasitize the larvae. Hence, the overall frequency of the whitefly transmitted viruses was low in the field. Cultivars Royal Red Kidney, Big Bend Red Mexican, Colombia Pinto, and Santa Ana were free from whitefly transmitted virus diseases. The first three cultivars possess resistance to Curly Top disease of beans. Cultivars Royal Red Kidney and Colombia Pinto were resistant to Rhynchosia mosaic in greenhouse inoculations at Río Piedras during May of 1973. The cultivar Santa Ana was free from Abutilon mosaic at Masaya, Nicaragua, in the Winter of 1972 and had shown resistance to Rhynchosia mosaic (RM) when inoculated during the Spring of 1972 at Río Piedras. No RM incidence has been encountered in the repeated plantings of this cultivar both at Isabela and at Mayaguez.

VII. Common Bean Mosaic Virus.--No incidence of CBMV disease was recorded during this trial.

VIII. Cercospora Leaf Spot.--Prolonged periods of high humidity and warm weather predispose bean leaves to infection by Cercospora cruenta or C. canescens. Cultivars Royal Red Kidney, Apollo, Pompadour K-2-1-2 and H-2-4, and 27R were susceptible to Cercospora leaf spot (CLS) diseases.

IX. White Mold.--Only pods of the cultivar Apollo were severely affected by white mold (Sclerotinia sclerotiorum). Apollo appeared to be especially susceptible to this fungus.

Response to Rainy Season Cultivation

Overall Response to Diseases.--Ecuador-299 had the best disease-free appearance, followed by Mexico-235 and Pompadour I-2-2-2 (Table 42). Cultivars such as 27R, Santa Ana and Royal Red Kidney suffered heavily from Rhizoctonia root rot and stem canker diseases. Southern blight and Rhizoctonia took a heavy toll in seedling stand. Ashy stem blight was not severe at the seedling stage, but its incidence increas as plants matured. The combination of foliage damage by bacterial blight disease and of peduncles damaged by ashy stem blight resulted in poor pod set and seed development. Other diseases were insignificant, except for white mold, that occurred in replicates 1 to 3 of cultivar Apollo severely affecting the green pods.

Yield.--Considering that: 1) no seed treatment was used, 2) seeds were planted in a highly infested field, 3) no chemical disease control treatments were applied to the plants, 4) continuous high humidity enhanced disease incidence, and 5) high temperatures affected pod set, it

Table 42.-Overall response to diseases by cultivars in Red Bean Yield Trial No. 2

Cultivar	Bacterial blight	Rust 1/	Cercospora leaf spot	Rhizoctonia root rot	Ashy stem blight	Whitefly transmitted viruses
Ecuador 299	S	0,0	---	---	---	S
Galana	HS	4,6	---	S	S-HS	S
Royal Red Kidney	S-HS	0,0	S	HS	S-HS	--
Big Bend Red Mexico	MS-S	5,9	---	S	S	--
Colombia Pinto	HS	5,9	---	HS	S-HS	--
Apollo	S-HS	0,0	S	S-HS	S	S
Mexico 235	S-HS	0,0	---	---	---	S
Santa Ana	S	5,9	---	S-HS	S	--
Pompadour K-2-1-2	HS	0,0	S	S-HS	S	S
Pompadour H-2-4	S	3,4	S	S-HS	S	S
Pompadour I-2-2-2	S-HS	1,0,5	--	S	---	S
27R	S-HS	0,0	S	S-HS	---	S

S = susceptible; HS = highly susceptible; MS = moderately susceptible

1/ Rust reaction recorded as function of pustule size

(0 = no infection to 5 = 500 microns or more in diameter) and intensity of infection (0-99%).

seems that a yield of 500 to 600 kilograms per hectare is indeed satisfactory (Table 44). Cultivars Colombia Pinto and Pompadour K-2-1-2 and I-2-2-2 were the highest yielders (Table 43). The high yield of Colombia Pinto was puzzling because plants of this cultivar had rather poor growth.

Adaptability.--The term "adaptability" here connotes the general vigor and growth of plants, the amount of disease-free foliage, and the ability to set pods at the relatively high diurnal temperatures. Sensitivity to day-length was considered separately, because, irrespective of climatic conditions, day-length sensitive plants continue to grow vegetatively, and fail to flower. Cultivars Santa Ana had the least vigorous growth. The cultivar Pompadour K-2-1-2 were the most growth vigorous among those with bush habit, Ecuador-299 and Mexico-235 had the overall most vigorous growth.

Summary of Results

The results of this field trial indicate that day-length sensitivity, resistance to diseases, and sensitivity to temperature are some of the most important factors that govern yield of beans under lowland humid tropical conditions.

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

The most widely resistant beans were: Ecuador-299 and Mexico-235. Unfortunately, both of these two cultivars are highly sensitive to day-length.

Table 43.-Yield data in the Red Bean Yield Trial No. 2, planted on 5/9/74 and harvested on 7/15-17/1974

Cultivar	Weight of beans (grams per replication					
	A	B	C	D	Total	Average
Ecuador 299	0.00	0.00	0.00	0.00	0.00	0.00
Galana	143.78	147.18	154.35	127.75	573.06	143.27
Royal Red Kidney	113.29	89.75	145.81	159.20	508.05	127.01
Big Bend Red Mexico	106.73	75.90	92.45	96.35	371.43	92.85
Colombia Pinto	128.95	158.65	192.00	346.05	825.65	206.41
Apollo	74.64	270.00	91.98	130.85	567.47	141.87
Mexico 235	0.00	0.00	0.00	0.00	0.00	0.00
Santa Ana	60.35	92.80	Dead	112.23	265.38	88.46
Pompadour K-2-1-2	153.15	132.90	129.74	299.45	715.24	178.81
Pompadour H-2-4	83.47	95.15	159.99	133.45	472.06	118.02
Pompadour I-2-2-2	151.54	184.35	140.00	191.85	667.74	166.94
27R	244.81	138.79	Dead	Dead	383.60	95.90

Table 44.-Field response, disease resistance, and Yield of red bean cultivars during the summer rainy season in Mayaguez

Cultivar	Field response	Disease resistance	Yield (Kg/Ha)
Ecuador 299	Well adapted, daylength sensitive, vine	Multiple resistance	0.0
Galana	Adapted with good pot set, low vine	Widely susc.	420.5
Royal Red Kidney	Moderately adapted, bush	Rust & RM:Res. but HS to R Root Rot	372.8
Big Bend Red Mexic(	Moderately adapted, tall bush to semi-vine	RM:Res. widely susc.	272.8
Colombia Pinto	Poorly adapted, bush, semi-vine	Widely susc.	605.0 Highest yield
Apollo	Moderately adapted	Widely susc. Rust Res.	416.5
Mexico 235	Well adapted; daylength sensitive, vine	Widely resistant	0.0
Santa Ana	Not adapted, semi-tall bush to semi-vine	RM:Res. Widely susc.	259.6
Pompadour K-2-1-2	Moderately adapted, upright plants, bush	Rust:Res. Widely susc.	524.9
Pompadour H-2-4	Moderately adapted, bush	Widely susc.	346.4
Pompadour I-2-2-2	Moderately well adapted, bush	AS Blt:Res. Widely susc.	490.0
27R	Adapted, bush	Widely susc. AS Blt:Res. ESP:RRoot Rot	281.3

b. Black Bean Trials

1. Adaptability, Disease Resistance, and Yield with Black Bean Cultivars from Central America (Trial No. 1)

Purpose, Materials and Methods

The purpose of this trial was to compare the performance of advanced selections of high yielding black beans from Central America for adaptability, disease resistance and yield during the summer rainy season at Mayaguez (sea level).

Cultivars.--Cultivars Jamapa, Porrillo No. 1, Criollo Santo Domingo, Venezuela-36 and 63, I-65, 51051, 51052, 51057, and 50600 were black beans included in the advanced yield trials of the Central American Cooperative Program for the Improvement of Edible Crops (PCCMCA). Cultivar Col-I-63-A was a red bean with Rhizoctonia root rot resistance from the Central American PCCMCA Trials. It was included for yield comparison. Cultivar La Vega is a high yielding multiple disease resistant release from Puerto Rico. This black bean cultivar was used as "local standard". The growth habit of these cultivars was either semi-vine or low-vine.

Methods.--The entire trial was exactly in the same way as the red bean trials. It was planted on 9 May and harvested on 15-16 July 1974.

Results

Germination

Seeds of cultivars 51057 and I-65 had the lowest germination (17% each) of the six trials conducted during this period. The highest percentages were those of 50600, La Vega, Venezuela-36 and Criollo Santo Domingo. As in the red beans, a major causa of low stand was infection of the seedlings by *R. solani* and *S. rolfsii*.

Diseases

I. Southern Blight.--Southern blight caused by S. rolfsii usually is most severe on seedlings from emergence up to three weeks. However, when beans are cultivated under high soil moisture, mortality due to southern blight may occur up to mature pod stage. Generally the incidence of mature plant mortality is much less than that of seedlings. Table 45 compares the percentage of seedlings growing 20 days after sowing with the percentage of mature plants 55 days after sowing. La Vega had 19% more plants by harvest time than at 3 weeks after emergence. This also indicates that there may be some latency factor in La Vega seeds. Stands of cultivars Venezuela-36, 51051 and 50600 remained constant throughout the trial. After the initial seedling loss, the surviving plants of 51057 and I-65 remained free from southern blight. From the other cultivars only a few mature plants were lost during the trial.

II. Rhizoctonia Root Rot and Stem Canker.--The lesion grading method described earlier was used in this trial. In addition, an intensity index was added to the recording. The reason for this was that the cultivars with high plant populations seemed to bear a high incidence of stem lesions. The intensity index indicates the number of plants infected. That is, "1" = 25% of plants infected, and "5" indicates 100% of plants diseased. Table 46 gives the response to Rhizoctonia at 50 days after sowing. Both cultivars La Vega and 50600 had over 50% Rhizoctonia stem canker. However, these lesions were intermediate in size. After the initial seedling mortality, the remaining mature plants in 51057 and I-65 had very little

Table 45.-Mature plants surviving 55 days after sowing, and comparison of the percentages of surviving to germinated plants (Black Bean Trial No. 1

Cultivar	Number of plants/rep.[1/] A	B	C	D	Total	Percent Germination	Percent Survival
La Vega	64	82	78	75	374	75	94
Porrillo No. 1	46	62	58	46	212	59	53
Jamapa	58	48	56	48	210	58	53
Criollo Sto. Domingo	68	74	62	67	271	71	68
Venezuela 36	71	78	73	69	291	73	73
Venezuela 63	60	55	51	55	221	61	55
51057	20	16	13	15	64	17	16
I-65	10	23	12	14	59	17	15
51052	61	62	55	53	231	60	58
Col.-I-63-A	46	55	57	45	203	55	51
51051	47	48	38	54	187	47	47
50600	77	74	82	83	316	78	79
Total	628	677	635	624	2564		

1/ 400 seeds sown per cultivar or 100 per replicate.

plants could have been the sparse stand in the rows which reduced shading and moisture.

III. Ashy Stem Blight.--Cultivar Col-I-63-A (a red bean included for comparison) was the only entry which was free from the ashy stem blight disease. Cultivars Porrillo No. 1, I-65 and 51052 could be considered as field resistant. The remaining cultivars were susceptible to this disease (Table 46).

IV. Bacterial Blight.--Bacterial blight was the severest leaf disease in this trial. The responses ranged from moderately susceptible (MS) to highly susceptible (HS) as shown in Table 46. All of the cultivars in this trial were susceptible to bacterial blight.

V. Whitefly Transmitted Viruses.--The data on incidence of whitefly transmitted viruses (WFTV) is summarized in Table 46. The frequency of golden yellow mosaic was five times more than that of Rhynchosia mosai Venezuela-63, La Vega, 50600 and Criollo Santo Domingo had very low percentages of diseased plants. Also, Venezuela-36, La Vega, 50600, 51052, and Porrillo No. 1 had only the golden yellow mosaic disease. Both Col-I-63-A and 51051 had relatively high incidence of WFTV diseases.

It seems that varietal differences in susceptibility to WFTV diseases do occur when cultivars are infested with a relatively low population of viruliferous whiteflies. Field observations in Central America tend to support the above conclusion. During the autumn planting on intermediate highlands, when the whitefly population is relatively low, many cultivars such as Porrillo No. 1 and Porrillo No. 70 are free from

Table 46.-Incidence of diseases and response of cultivars to causal agents - (Black Bean Trial No. 1)

Cultivar	Rhizoctonia stem canker[1/]	Ashy stem blight	Bacterial blight	Whitefly transmitted viruses (% infection)
La vega	MS, 1.7	S	S-HS	0.8
Porrillo No. 1	NI	SS	S	4.2
Jamapa	NI	S	HS	3.8
Criollo Sto. Domingo	1.0	S	S-HS	1.8
Venezuela 36	NI	S	HS	0.7
Venezuela 63	MS, 0.7	S	HS	0.0
51057	MS, 1.0	-	MS-S	12.5
I-65	MS, 1.0	SS	MS-S	3.4
51052	MS, 1.2	SS	HS	4.3
Col.-I-63-A	NI	R	HS	31.5
51051	S, 2.0	MS	MS-HS	34.8
50600	MS, 2.5	S	HS	1.3

1/ Includes lesion size (SS to HS), and intensity (1-5).

GYM disease. At the same time numerous other cultivars may be 5 to 20% diseased. However, all these cultivars may become severely diseased when they are planted during the winter dry weather under irrigation. The differential response of the cultivar Santa Ana to Rhynchosia mosaic at Masaya, Nicaragua, in the winter of 1972, was an striking example of field resistant beans to WFTV diseases.

VI. Rust.--Only cultivar Col-I-73-A was moderately infected with rust, the rest of the entries in the trial were free from rust infection.

Maturation

The red seeded cultivar Col-I-63-A was the only early maturing entry; La Vega, Criollo Santo Domingo, Venezuela-36 and 63, and 50600 were early to mid-season in maturation; Porrillo No. 1, Jamapa and 51052 were mid- to late season; and 51057 and I-65 were late maturing.

Yield

The yield of the cultivars in this trial closely reflected the extent of their resistance to diseases, especially to soil-borne diseases (Table 47). For example, the yield in Replicate "A" for La Vega reveals the compounding effect of high incidence of Rhizoctonia stem canker and Xanthomonas bacterial blight (Tables 46 and 47). In Replicate "D" of Porrillo No. 1, the combination of moderately low stand and ashy stem blight disease were most likely the cause of low yield (Table 45). The surviving mature plants of cultivars 51057 and I-65 were apparently the individuals with high resistance, because none of these plants showed any significant root rot or ashy stem blight lesions. Perhaps, it was the combination of this resistance and sparse stand that resulted in

Table 47.-Summary of yield data (Black Bean Yield Trial No. 1)

Cultivar	Weight (grams)		Yield	
	Total	Average per replication	Total/plant (grams)	Kilograms per hectare
a Vega	1869.07	467.26	5.00	1371.6
orrillo N	978.28	244.57	4.61	717.9
amapa	1239.65	309.91	5.90	909.7
riollo Sto. Domingo	1557.05	389.26	5.75	1142.7
enezuela 36	1562.56	390.64	5.35	1146.7
enezuela 63	1140.08	285.02	5.16	836.7
51057	861.57	215.39	13.46	632.3
-65	1020.54	255.13	17.30	748.9
51052	1283.66	320.91	5.56	942
Col.-I-63-A	1194.10	298.52	5.88	876.3
51051	356.24	89.06	1.90	261.4
50600	1464.58	366.14	4.63	1074.8

Date of Planting: 5/9/74

Date of Harvest: 7/12/74 - 7/23/74

Location: Las Gómez, MITA, Mayaguez, ...

2.5 to 3.5 times more yield per plant (Table 47). The main reasons for low yields in Replicates "A" and "B" of 51051 was the high incidence of early infection by GYM. On the other hand, the severe incidence in Replicate "C" of Col-I-63-A occurred after pods were set. Hence the disease had little effect on the yield. Another factor which affects the marketable yield is the suscpetibility of seeds to infections. For example, about 15% of seeds in Venezuela-63 and 40% of seeds in 51057 were diseased. For overall yield, cultivars La Vega, Criollo Santo Domingo, and 50600 were outstanding.

Summary of Results

Soil-borne pathogens seriously limit the yield potential of a bean cultivar. During the summer rainy season they cause severe loss of stand among susceptible cultivars.

Bacterial blight caused by Xanthomonas species is a major foliar disease.

Whitefly transmitted viruses (WFTV) when occurring before flowering, cause a severe loss in yield. However, if these diseases occur after pod set yield is not affected.

There was a distinct and significant differential response to WFTV in this trial. Cultivars Col-I-63-A and 51051 were the most susceptible.

There was five times more GYM incidence than RM.

La Vega was the highest yielding cultivar, followed by Criollo Santo Domingo and 50600.

2. Yield Trial of Black Bean Cultivars and Advanced Lines (Trial No. 2)

Purpose, Materials and Methods

Several black bean lines have been developed during the past 6 years by the Edible Legume Project. These were released by the USDA during 1973-74 as multiple disease resistant advanced lines. This trial was conducted to compare the performance of these materials with cultivars used in commercial production in Central America. The reasoning was that if these plants could produce well without disease control during the rainy season while growing on heavily infested soil, then they could yield well in small farm cultivation.

Material.--Cultivar La Vega was used as the "local standard", while Porrillo No. 1 and Jamapa were included as Central American commercial black beans. Mexico-309, an outstanding entry in 1970-72 PCCMCA trial, was included as a high yielding multiple disease resistant advanced line from Central America. The eight multiple disease resistant black bean releases were developed by the Project. These were: 1) 15R-42 - common bean mosaic (CBMV), rust and soil-borne disease resistant; 2) 15R-52 - same as (1); 3) 15R-55 - same as (1); 4) 15R-57 - CBMV susceptible, but resistant to rust and soil borne diseases; 5) 15R-87 - same as (4); 6) 71-1R-101 - CBMV and soil-borne disease resistant; 7) 71-1R-113 - same as (6); and 8) 71-1R-136 - same as (6).

Method.--The same field methods described for previous trials were employed. The major factor was the absence of disease control. The trial was planted on 9 May 1974 and harvested on 18-23 July 1974, at Las Gomez, MITA, Mayaguez, Puerto Rico.

Results

Germination and Seedling Stand

The overall resistance of the entries to soil-borne diseases is reflected in the very good seedling stand 20 days after sowing (Table 48). The incidence of southern blight and Rhizoctonia root rot was very low among these seedlings. The mature plant stand was the same as the seedling count.

iseases

The main foliar disease in this trial was bacterial blight. All entries were susceptible to this disease. Cultivar 15R-55 is consider-›ly field tolerant to bacterial blight. Cultivars 15R-57 and 15R-87 ›re both infected with CBMV. Golden yellow mosaic, a whitefly trans-ltted virus disease, appeared late, and at very low levels in this ›ial, and had little effect on the yield of the entries. Ashy stem light incidence was high in cultivars 71-1R-101 and 71-1R-136.

Yield

Table 49 provides the summary of the yield data for this trial. ›e trial was centrally located in relation other trials at Las Gomez, ›d both soil and the growth of the plants were most uniform. However, t appears that the main reason for the uniform yields (see Average Re-licate Yield, Table 49) among replicates in this trial was the general ›sistance to soil-borne diseases of the entries. The analysis of var-›nce for the yield data indicated that the differences in the yields f the selections were significant at 1% level of probability. The ›ncan's Multiple Range Test was done for the mean yields of the

Table 48.-Seedling stand 20 days after sowing (Black Bean Yield Trial No. 2)

Cultivar	Number of Seedlings					Percent of seeds sown 1/
	Rep. A	Rep. B	Rep. C	Rep. D	Total	
La Vega	87	81	89	72	329	82
Jamapa	70	68	77	78	293	73
Porrillo No. 1	82	86	86	81	335	84
15R-52	67	59	71	65	262	66
15R-55	74	71	67	87	299	75
15R-57	80	70	65	83	298	75
15R-42	84	81	81	90	336	84
15R-87	72	77	82	80	311	78
71-1R-101	67	82	63	73	285	71
71-1R-113	70	53	80	66	269	67
71-1R-136	60	69	66	74	269	67
Mexico 309	91	82	94	96	363	91

1/ 400 seeds in four replicates of 100 seed each.

Table 49.-Yields of cultivars in Black Bean Yield Trial No. 2, planted on May 9 and harvested on July 18-23, 1974

Cultivar	Weight of beans (grams) per Replication				Total	Average
	A	B	C	D		
La Vega	241.15	336.55	393.45	343.00	1,314.15	328.55
Jamapa	324.25	393.55	326.20	336.03	1,380.03	345.01
Porrillo No. 1	260.75	264.15	286.30	370.58	1,181.78	295.45
15R-52	350.45	246.15	391.30	242.95	1,230.86	307.72
15R-55	359.25	298.95	399.65	404.48	1,462.33	365.58
15R-57	231.25	241.30	249.55	228.25	950.35	237.59
15R-42	369.45	315.75	422.75	347.00	1,454.95	363.74
15R-87	208.35	236.65	218.15	262.80	925.95	231.49
71-1R-101	246.4	178.75	182.09	199.45	806.69	201.67
71-1R-113	329.35	321.95	346.65	352.83	1,350.78	337.70
71-1R-136	236.7	283.35	307.90	267.50	1,095.45	273.86
Mex. 309	401.60	386.15	363.50	312.98	1,464.23	366.06
Total	3,558.95	3,503.25	3,887.45	3,657.85	4,617.55	
Replicate average	296.58	291.93	323.93	304.82	1,218.13	304.54

ltivars (Table 50). The results indicate that Mexico-309 and 15R-55, R-42, Jamapa, and 71-1R-113 were the high yielding cultivars, while Vega, 15R-52, and Porrillo No. 1 were the intermediate yielding cul- vars, and 71-1R-136, 15R-57 and 71-1R-101 were the low yielders in this ial. Again it should be noted that cultivars affected by diseases were e lowest yielding entries. Since all entries were affected by bacterial ight, the effect on this disease on the yield of the cultivars should uniform. Selections affected by additional diseases, such as ashy em blight in 71-1R-101 and 71-1R-136, and CBMV in 15R-57 and 15R-87, owed corresponding loss in yield.

Diseased Seed.--There was an excessive amount of diseased seeds in is trial, possibly due to the fact that pods had to be harvested wet d were stored until threshed. Whatever the cause, these data should flect the relative susceptibility of seeds of each cultivar to fungal d bacterial diseases.

nclusions

1) Resistance to soil-borne diseases is an important component af- fecting bean yields in lowland tropical soils.
2) Besides resistance to soil-borne diseases, a bean cultivar for the tropics requires resistance to viruses, as well as fungal and bacterial blights in order that its yield could approach commercial standards.
3) Four years of screening and breeding in Puerto Rico has pro- duced high yielding advanced lines.

Table 50.-Comparison of Yield Data and Diseased Seed in the Black Bean Trial No. 2

Cultivar	Average yield (grams)	Duncan Range Test 1/	Yield per plant (grams)	Yield kilogram/ hectare	Percent damaged seed 2/
Mexico 309	366.06	a	4.03	1,074.6	15
15R-55	365.58	ab	4.90	1,073.0	15
15R-42	363.74	ab	4.33	1,067.8	50
Jamapa	345.01	abc	4.71	1,012.8	40
71-1R-113	337.70	abc	5.02	991.3	50
La Vega	328.55	abcd	3.99	964.5	25
15R-52	307.72	bcd	4.69	903.3	15
Porrillo No. 1	295.45	cde	3.82	866.0	50
71-1R-136	273.86	de	2.95	803.9	40
15R-57	237.59	ef	3.19	697.5	30
15R-87	231.49	ef	2.96	679.5	50
71-1R-101	201.67	f	2.83	592.0	5

1/ Averages with similar letters do not differ at the 1% level of probability.

2/ Fungal and bacterial infections were the major cause of seed damage.

3. Yield Trial with Advanced Lines Selected for the Rainy Season (Trial No. 3)

Purpose, Materials and Methods

Beans and cowpeas grown during May-July at Isabela had a high incidence of bacterial blight (*Xanthomonas* strains) and web blight (*Thanatephorus cucumeris*) diseases. It was thought that a yield trial of the selected black beans, in the same field, could provide information on the relative responses of the cultivars to the two diseases.

Materials.--Cultivar La Vega was used as the "local standard", while Mexico 309, Venezuela-36, 51052 and 50600 were included as selected Latin American black beans. These cultivars are high yielding and possess resistance to at least two diseases. Eight multiple disease resistant black beans developed by the Project were selected for this trial. These were 15R-42, 15R-52 and 15R-55, which have resistance to CBMV, rust and soil-borne diseases; 15R-57 and 15R-87, which are susceptible to CBMV and soil-borne diseases.

Methods.--No disease control measures were used in this trial. Seeds were not treated with pesticides, soil was not treated, and no foliage application of fungicides was used. Rainfall was abundant, resulting in sparse insect pests, hence no insecticide was applied. The number of seeds per replication and planting arrangements were the same as those described for previous trials. The trial was sown on 9 August 1974 and harvested 17 October 1974.

Results

Diseases

The main diseases in this trial were Rhizoctonia stem canker and web blight, and bacterial blight. Ashy stem blight was present, but a low incidence level

I. Rhizoctonia stem canker.--The replicated blocks were placed in East to West direction, while there was a slight North to South slant to the field. Hence, Replicate "A" was 4 to 6 inches lower than Replicate "D". This difference in elevation resulted in greater humidity in the soils of Replications "A" and "B". This occurred in spite of the raised rows. There was a greater incidence of stem canker among the plants on these lower beds. The effect of higher humidity and frequency of stem canker was reflected in the growth index of the plants (Table 51). The range of growth index for Replicate "A" was 4.30-6.38, while for Replicate "D", it was 7.07-8.76, an index of 10 being the most vigorous growth indicating plants 18-24 inches tall. Among the cultivars, 15R-57 and 71-1R-101 had the lowest range of growth 40 days after sowing. At this stage, lesions from basidial infections (web blight) began to appear on the lower leaves. Only 15R-55, 15R-87 and Mexico-309 were free from these lesions.

II. Bacterial Blight.--Thirty days after sowing, bacterial blight began to appear in the plots. Ten days later almost all replicates were diseased (Table 52). Cultivars 51052 and Mexico-309 were heavily infected. Cultivars 71-1R-136, 71-1R-113 and 15R-87 were classified as tolerant in this test. Both in this trial and in other field plantings, cultivar

Table 51.-Growth index of cultivars 40 Days after sowing. (Black Bean Trial No. 3)

Cultivar	Range of growth index per replication				Average
	A	B	C	D	
La Vega	6-7	6-6	6-8	8-9	6.50-7.50
Venezuela-36	5-7	7-8	9-9	10-10	7.75-8.50
51052	4-5	5-7	7-8	8-10	6.00-7.50
50600	5-6	5-5	7-8	8-9	6.25-7.00
15R-52	5-7	6-6	6-9	5-6	5.50-7.00
15R-55	4-5	7-9	7-9	7-10	6.25-8.25
15R-57	2-5	4-5	4-6	8-10	4.50-6.50
15R-42	5-7	6-7	8-8	7-9	6.50-7.75
15R-87	4-7	6-8	5-8	5-8	5.00-7.75
71R-1R-101	4-5	3-5	4-7	7-8	4.50-6.25
71-1R-113	3-7	5-6	3-5	6-8	4.25-6.50
71-1R-136	4-7	4-7	7-8	6-7	5.25-7.25
Mexico-309	5-8	6-8	7-9	7-10	6.25-8.75
Rep. Total Range	56-83	70-81	80-102	92-114	
Average	4.30-6.38	5.38-6.69	6.15-7.84	7.07-8.76	

1 = 4 inches tall to 10 = 18 inches tall

Table 52.-Response of 40-day old black bean cultivars to bacterial blight (*Xanthomonas* strains) during rainy season at Isabela. (Black Bean Trial No. 3)

Cultivar	Disease rating in replicates				Overall
	A	B	C	D	
La Vega	S	-	S	S	-
Venezuela-36	S	S	S	S	S
51052	-	HS	HS	S	HS
50600	S	-	S	-	S
15R-52	SS	S	S	S	S
15R-55	S	-	S	S	S
15R-57	S	MS	S	S	S
15R-42	S	S	S	S	S
15R-87	SS	S	MS	S	MS-S
71-1R-101	S	-	S	MS	S
71-1R-113	-	-	MS	S	MS
71-1R-136	S	-	-	MS	MS-S
Mexico-309	HS	MS	HS	HS	HS

15R-87 seemed to segregate for susceptibility to bacterial blight. The rest of the entries were susceptible. The combined effect of bacterial blight, Rhizoctonia stem canker, and basidial lesions on the lower leaves was chlorosis of the foliage. The chlorosis began about 35 days after sowing, and at 40 days the replicates in block B had more chlorotic leaves than those in other blocks.

III. Basidial Infection of T. cucumeris.--Sixty days after planting, it seemed that there was not a single leaf in the plot which was not covered by lesions incited by the basidial stage of T. cucumeris These small round lesions with purplish borders were often so numerous that they coalesced into an entire necrotic mass, resulting in defoliation. Table 53 gives the growth index of the cultivars at this stage. Cultivars La Vega, 15R-55 and Mexico-309 had the highest growth index. Table 54 gives the response of the cultivars to basidial infection. It was interesting to note that replicates differed very slightly, but there was considerable difference between the cultivars. For example, La Vega was almost twice as much susceptible as 15R-55. Also Mexico-309 and 71-1R-101 were not as severely affected as the rest of the cultivars. Table 55 gives the percentages of defoliation among the cultivars at this stage. Cultivars 15R-55, 71-1R-136 and Mexico-309 were the least defoliated, while 15R-57 and La Vega were heavily defoliated. Sixty-five days after planting, or 5 days after the last recording of data, all cultivars were leafless. The severity of the basidial infection was so great that leaves fell without allowing the mycelia time to develop the web stage of the disease. Seventy days after planting all plants were uprooted and hung up to dry. Table 56 gives the summary of the yield data.

Table 53.-Growth index of cultivars 60 days after sowing (Black Bean Trial No. 3)

Cultivar	Range of growth index per replicate				Average
	A	B	C	D	
La Vega	8-10	9-10	10-10	10-10	9.25-10
Venezuela-36	7-9	9-10	9-10	9-10	8.50-9.75
51052	3-5	7-7	5-6	7-9	5.50-6.75
50600	5-8	6-7	8-8	9-9	7.00-8.00
15R-52	7-8	8-8	8-10	8-9	7.75-8.75
15R-55	7-9	0-10	9-10	10-10	9.00-9.75
15R-57	3-5	4-5	5-7	8-10	5.00-6.75
15R-42	6-8	9-10	9-9	9-10	8.25-9.25
15R-87	7-8	8-10	8-10	7-10	7.50-9.50
71-1R-101	5-7	4-10	4-10	5-10	4.50-9.25
71-1R-113	5-7	9-10	8-8	6-10	7.00-8.75
71-1R-136	8-8	9-10	10-10	7-7	8.50-8.75
Mexico 309	9-9	9-10	9-10	9-10	9.00-9.75
Replicate total	80-101	101-117	102-118	104-124	
Replicate average	6.15-7.76	7.76-9.00	7.84-9.07	8.00-9.53	

Table 54.-Response of 60-day old black bean cultivars to basidial infection (*Thanatephorus cucumeris*) during the rainy season at Isabela (Black Bean Trial No. 3)

Cultivar	Disease Index[1/] per Replicate				Average
	A	B	C	D	
La Vega	8	8	8	9	8.2
Venezuela-36	6	7	5	5	5.7
51052	7	6	6	5	5.8
50600	5	6	4	6	5.2
15R-52	4	6	6	5	5.2
15R-55	5	4	4	4	4.2
15R-57	7	8	6	6	6.7
15R-42	5	5	5	5	5.0
15R-87	6	6	6	4	5.5
71-1R-101	5	4	6	4	4.7
71-1R-113	7	7	4	4	5.5
71-1R-136	4	4	8	4	5.0
Mexico 309	5	6	4	4	4.7
Replicate total	74	77	72	74	
Replicate average	5.69	5.92	5.53	5.69	

1/ 1 = no basidial lesion on leaves to 10 = all leaves heavily infected.

Table 55.-Percent defoliation of black bean cultivars due to severe incidence of basidial infection by *Thanatephorus cucumeris* 60 days after planting

Cultivar	Percent defoliation per replicate				Average
	A	B	C	D	
La Vega	90	85	75	95	86.25
Venezuela-36	75	80	50	50	63.75
51052	85	60	60	50	63.75
50600	75	60	40	50	56.25
15R-52	40	70	60	60	57.50
15R-55	50	30	20	20	30.00
15R-57	85	90	60	50	71.25
15R-42	40	50	50	50	47.50
15R-87	60	60	50	40	55.00
71-1R-101	60	40	70	50	55.00
71-1R-113	80	80	75	30	66.25
71-1R-136	30	35	75	30	42.50
Mexico 309	50	60	30	30	42.50
Replicate total	820	740	725	605	
Replicate average	63.07	56.92	55.76	46.53	

Table 56.-Yield data for Black Bean Yield Trial No. 3

Cultivar	Yield in Grams					
	Rep. A	Rep. B	Rep. C	Rep. D	Total	Average
La Vega	74.15	76.90	95.10	54.45	300.60	75.15
Ven.-36	73.05	74.70	107.60	149.60	404.95	101.22
51052	30.92	89.10	96.90	132.05	348.98	87.24
50600	71.60	69.39	90.30	55.15	286.64	71.61
15R-52	59.55	66.45	59.80	42.15	227.95	56.48
15R-55	114.70	132.40	154.40	138.15	539.60	134.91
15R-57	26.00	22.50	64.39	140.95	253.85	63.46
15R-42	79.55	66.60	127.10	92.55	365.80	91.45
15R-87	49.80	50.10	40.30	87.20	227.40	56.85
71-1R-101	7.80	36.89	34.90	30.75	110.34	27.58
71-1R-113	44.20	29.30	46.50	93.15	213.05	53.28
71-1R-136	116.60	100.00	123.00	112.20	451.80	112.95
Mex. 309	120.60	63.89	115.70	150.30	450.49	112.62
	868.52	878.22	1115.99	1278.65		

Yield

In this trial all cultivars grew uniformly. For example, they flowered within 34 to 37 days, were denuded of leaves, and all had mature pods at the same time. As the data in Table 56 indicates the yield of block A was the lowest and that of block D was the highest. This gradation occurred almost throughout the trial. However, what was surprising was the wide differences between the yields of the cultivars. For example, cultivar 15R-55 yielded five times more than 71-1R-101. The high yielding cultivars in this trial were: 15R-55, 71-1R-136, Mexico-309 and Venezuela-36.

Conclusion

Bean cultivars vary in their level of susceptibility to web blight, Cultivar 15R-55 has high tolerance to bacterial blight and soil-borne diseases. Cultivar Mexico-309 also has high tolerance to soil-borne diseases. However, under field stress due to diseases and climate its seeds have a tendency to become flat.

c. Rust Resistance Trials

1. Adaptability Trial of Rust Resistant Advanced Lines

Purpose, Materials and Methods

The late spring and the summer rainy seasons in the lowland tropics are unfavorable periods for bean production. In these seasons some varieties produce considerable vegetative growth and there may be a complete absence of flower formation in others. The high ambient temperatures reduce pod set while rains and high humidity increase disease incidence. Only a multiple disease resistant, day-length and temperature insensitive cultivar can yield satisfactorily during the tropical rainy season.

These rust trials were planned to favor disease incidence. Seeds were not treated against soil-borne diseases and no foliar fungicides were applied during the trial. Insecticides were applied when required.

The rust trials included two plantings, one at the Lajas Substation (from 24 April - 5 July 1974) and another at the Federal Experiment Station at Mayaguez (from 15 May - 19 July 1974). Both trials consisted of 30 entries planted in a complete randomized block design in three replicates. Each plot consisted of 30 seeds planted in two five-foot rows 18 inches apart. Plots were 3 feet apart and blocks were separated by 3-foot alleys. The Lajas trial was mainly used for recording rust reaction, while detailed disease incidence data were gathered from the Mayaguez trial. Cultivars Jamapa, Galana and La Vega were used as standards.

An overhead irrigation system was set up in the Mayaguez plot for the duration of the trial. If no rainfall occurred within two consecutive days, overhead irrigation was applied to maintain high moisture levels in the field.

In the Lajas trial, the standard cultivar La Vega was replaced by the rust differential variety Bountiful-181, which is highly susceptible to rust. The purpose of this change was to record rust intensity at Lajas.

Results

Germination

The planting of untreated seeds in a soil heavily infested with soil-borne pathogens resulted in low seedling stands in a number of

cultivars. The reduction in seedling stand in the disease plot at FES, Mayaguez, was mostly due to two types of fungus diseases. These were pre-emergence losses caused by Rhizoctonia and post-emergence losses due to Macrophomina phaseoli (ashy stem blight). Rhizoctonia also caused some post-emergence loss but principally caused gradual decline of the plants rather than seedling death after emergence. Cultivars 71-1R-103, Ecuador-299, Royal Red Kidney, 27R, and Galana were highly affected by pre-emergence Rhizoctonia rot (Table 57). A difference in germination was noted between the seeds of Galana sown at Lajas and those sown at Mayaguez (Table 60). Seedling mortality in 15R-69, both at Lajas and Mayaguez, was due to ashy stem blight (Table 60).

The average germination percentage for Lajas was 62.4 and for Mayaguez was 66.9. The two values were rather similar, but the causes of the relatively low germinations in the two locations were different. The major factors for the low germinations were soil-borne diseases at Mayaguez and excessive moisture levels in the heavy soils at Lajas.

Diseases

I. Common bean mosaic virus (CBMV).--Severe natural infection occurred both at Lajas and Mayaguez.

II. Whitefly transmitted viruses (WFTV).--Heavy rains usually decrease the whitefly (Bemisia tabaci) population in the field and hence reduce the incidence of WFTVs, such as Rhynchosia mosaic (RM) and golden yellow mosaic (GYM). However, both diseases were severe in the Mayaguez trial. Infections occurred at two stages of plant growth: a low incidence at the seedling stage and a severe outbreak after pod set.

Table 57.-Germination of bean untreated seeds of rust resistant selections in a pathogen-infested field at FES, Mayaguez

Cultivar	Number of seedlings per replication			Total	Percent germination
	A	B	C		
15R-42	26	24	25	75	83.0
15R-52	21	21	13	55	61.1
15R-55	16	22	26	64	71.1
15R-57	28	27	24	79	87.8
15R-63	20	16	13	49	54.4
15R-66	23	22	27	72	80.0
15R-69	7	7	9	23	25.5
15R-87	24	26	27	77	86.5
71-1-R-101	23	24	25	72	80.0
71-1-R-103	13	9	13	35	38.9
71-1-R-113	25	17	23	65	72.2
71-1-R-136BK	23	21	18	62	68.9
15R-148	27	29	28	84	93.3
15R-167	21	21	23	65	72.2
15R-167P	27	21	19	67	74.4
15R-180	21	22	23	66	73.3
15R-189	11	21	18	50	55.5
15R-193	25	25	28	78	86.7
15R-194	25	29	21	75	83.3
15R-210	13	14	23	50	55.5
15R-217	14	19	15	48	53.3
15R-287	28	29	27	84	93.3
15R-292	22	25	22	69	76.7
Mex. 235	27	25	28	80	88.9
Ecuad. 299	12	14	18	44	48.9
27R	7	24	22	53	58.9
Royal Red Kidney	7	7	5	19	21.1
Jamapa	20	19	17	56	62.2
La Vega	30	26	30	86	95.5
Galana	1	2	1	4	4.4

Planted: 5/15/74, 30 seeds per replication.
Recorded: 6/5/74.

III. Bacterial blight.--Severe natural infection occurred throughout the trial. However, some cultivars such as 15-R66, despite their high degree of susceptibility to the bacterial blight strains, produced acceptable yields (Table 58).

IV. Rhizoctonia root rot.--The field in Mayaguez was severely infested with Rhizoctonia. Many lines with poor germination also contained plants that had Rhizoctonia stem canker and root rot disease.

V. Rust.--Natural infection served as inoculum at Lajas, while field inoculum was provided at Mayaguez by heavily rusted bean plants that were grown in the greenhouse. As Table 58 indicates, the rust population at Lajas differed from that in Mayaguez. The rust race or races at Mayaguez were more widely virulent than those at Lajas. However, at Lajas, due to drier climate, rust intensity was more severe than at Mayaguez.

Yield

No yield data was gathered from the Lajas trial. The summary of the yield data of the Mayaguez trial is presented in Table 59. Cultivars La Vega, Jamapa, 15-R66, 15-R55, 71-1-R136-BK, 15-R42 and 15-R292 produced the best yields in the trial. The following cultivars produce the highest yields per plant: Jamapa, La Vega, 15-R66, 71-1-R-136-BK, 15-R55, 15-R42, Royal Red Kidney and 71-1-R113.

Selection of Best Adapted Cultivars and Lines

Cultivars Mexico-235 and Ecuador-299 were the least adaptable for the summer planting. Neither flowered during the trial period, but both grew vegetatively. Cultivars 15-R63, 15-R69, 71-1-R103, Royal Red Kidney, 15-R210, and 15-R277 were not well adapted (Tables 58, 59, and 60).

Table 58.-Response of rust resistant bean selections to other pathogens during the rainy period of 4/24 to 7/19/74

Cultivar	CBMV	Rust		WFTV		Bact. blight	Rhiz. root rot	Adapta-bility	Field selections	Remarks
		Lajas	Maya-guez	RM	GYM					
15-R42	--	--	--	--	S	HS	--	5	+++	
15-R52	--	--	3	--	--	HS	--	5	+	
15-R55	--	--	--	--	--	MR	--	5	+++	
15-R57	--	--	2	--	S	HS	--	3	--	
71-1-R63	S	--	--	HS	S	HS	--	1	--	
15-R66	---	--	3	--	MS	HS	--	5	++	
15-R69	S	5	--	S	S	HS	--	1	--	Ashy stem blight severe
15-R87	--	--	--	--	HS	MS	Res.	4	+	
71-1-R101	--	--	3	--	MS	HS	S	3	--	
71-1-R103	--	--	--	S	HS	HS	S	1	--	
71-1-R113	--	--	--	MS	S	MS	--	3	+	
71-1-R136-BK	--	--	--	S	MS	S	--	5	+++	
15-R148	S	--	--	--	S	MS	Res.	4	+	Good stand
15-R167	HS	--	--	--	MS	S	Res.	4	--	Excellent stand
15-R167-P	S	2	--	S	S	HS	--	3	--	

Table 58.-Cont.

Cultivar	CBMV	Rust		WFTV		Bact. blight	Rhiz. root rot	Adapta-bility	Field selection	Remarks
		Lajas	Maya-guez	RM	GYM					
15-R-180	HS	--	--	S	HS	--	--	4	--	
15-R189	--	--	--	MS	S	MS	S	4	--	
15-R193	--	--	--	S	S	S		4	+	
15-R194	--	--	--	S	S	S	S	4	--	
15-R210	--	5	--	HS	--	HS	--	2	--	
15-R277	--	5	4	HS	--	HS	--	2	--	
15-R287	HS	--	--	HS	HS	HS	Res.	3	--	
15-R292	S	--	--	S	S	HS	--	3	--	
Mex. 235	S	--	--	MS	--	S	--	Veget.	--	
Ecuad. 299	--	--	--	HS	HS	S	--	Veget.	--	
27-R	--	5	--	S	--	HS	HS	3	--	
Royal Red Kidney	--	--	--	--	--	HS	--	1	--	
Jamapa	--	2	4	--	MS	HS	--	5	++	
La Vega	--	--	--	--	MS	S	--	5	+++	Good stand
Galana	--	--	5	--	--	HS	--	1		

Table 58.-Cont.

Diseases: Common Bean Mosaic Virus (CBMV)
Rust (*Uromyces appeudiculatus*)

White Fly Transmitted Viruses (WFTV)
Rhynchosia Mosaic (RM) and Golden Yellow Mosaic (GYM)

Bacterial Blight (*Xanthomonas Strains*)

Rhizoctonia Root Rot (*Rhizoctonia solani*)
Ashy Stem Blight (*Macrophomina phaseoli*)

Rust Index:
Rust: 5 = Highly susceptible to 1 = Resistant

Disease Response:
HR = Highly resistant; R = Resistant; MR = Moderately resistant;
MS = Moderately susceptible; S = Susceptible; HS = Highly susceptible

Adaptability Index: 5 = Highly adaptable; 1 = Poorly adaptable

Field Selection: Highly desirable = +++ to Reject = -

Table 59.-Rust resistance bean trial - Summary of the yield data

Cultivar	YIELD		
	Average per plot (grams)	Average per plant (grams)	Hectare (kilograms)
1. 15R-42	520.4	6.9	509.3
2. 15R-52	419.3	7.6	410.3
3. 15R-55	583.1	9.1	580.6
4. 15R-57	191.9	2.4	281.6
5. 71-1R-63	73.0	4.5	71.0
6. 15R-66	649.6	9.0	635.7
7. 15R-69	33.2	1.4	32.5
8. 15R-87	277.6	3.6	407.5
9. 71-1R-101	147.2	2.0	144.0
10. 71-1R-103	36.6	1.0	53.7
11. 71-1R-113	445.6	6.8	436.0
12. 71-1R-136 BK	537.0	8.6	525.4
13. 15R-148	282.6	3.3	276.6
14. 15R-167	323.2	4.9	316.3
15. 15R-167P	254.1	3.7	248.6
16. 15R-180	169.9	2.5	166.3
17. 15R-189	256.0	5.1	250.4
18. 15R-193	404.9	5.1	396.3
19. 15R-194	257.4	3.4	251.9
20. 15R-210	110.7	2.2	108.3
21. 15R-277	148.6	3.0	145.4

Table 59.-Cont.

Cultivar	YIELD		
	Average per plot (grams)	Average per plant (grams)	Hectare (kilograms)
22. 15R-287	367.14	4.37	509.3
23. 15R-292	515.11	7.46	504.0
24. Mex. 235	---	--	---
25. Ecuad. 299	---	--	---
26. 27-R	309.02	5.83	302.3
27. Royal Red Kidney	129.22	6.8	126.4
28. Jamapa	688.92	12.3	674.0
29. La Vega	907.16	10.55	887.6
30. Galana	---	--	---

Date Planted: 5/15/74

Date Harvested: 7/19/74-8/5/74

Location: Las Gomez, FES, Mayaguez, P.R.

Table 60.-Selection of rust resistant bean cultivars for adaptability to the humid lowland tropical environment in Puerto Rico

Cultivar	Percent germination		Adaptability Index	Yield (Kg/Ha)	Selection	
	Lajas	Mayaguez			Field	Final
15-R-42	85.5	83.0	5	509.3	+++	++
15-R52	75.0	61.1	5	410.3	+	+
15-R55	77.0	71.1	5	580.6	+++	++
15-R57	91.0	87.8	3	281.6	--	--
71-1-R63	55.5	54.4	1	71.0	--	--
15-R66	84.4	80.0	5	635.7	++	++
15-R69	25.5	25.5	1	32.5	--	--
15-R87	77.0	86.5	4	407.5	+	+
71-1-R101	50.0	80.0	3	144.0	--	--
71-1-R103	53.0	38.9	1	53.7	--	--
71-1-R113	53.0	72.2	3	436.0	+	+
71-1-R136-BK	70.0	68.9	5	525.4	+++	++
15-R148	68.0	93.3	4	276.6	+	+
15-R167	43.0	72.2	4	316.3	--	+
15-R167-P	63.0	74.4	3	248.6	--	--
15-R180	70.0	73.3	4	166.3	--	--
15-R189	52.0	55.5	4	250.4	--	--
15-R193	91.0	86.7	4	396.3	+	+
15-R194	64.4	83.3	4	251.9	--	--
15-R210	72.0	55.3	2	108.3	--	--
15-R277	46.6	53.3	2	145.4	--	--
15-R287	73.0	93.3	3	359.2	--	+

Table 60.-Cont.

Cultivar	Percent germination		Adaptability Index	Yield (Kg/Ha)	Selection	
	Lajas	Mayaguez			Field	Final
15-R292	65.5	76.7	3	504.0	--	++
Mex.-235	44.0	88.9	Veget.	--	--	--
Ecuad.-299	35.5	48.9	Veget.	--	--	--
27-R	56.6	58.9	3	302.3	--	+
Royal Red Kidney	33.0	21.1	1	126.4	--	--
Jamapa	55.5	62.2	5	674.0	++	++
La Vega	--	95.5	5	887.6	+++	+++
Galana	94.4	4.4	1	--	--	--

Selection: Highly desirable = +++ to Reject =

The most adaptable selections include: La Vega, Jamapa, 15-R42, 15-R55, 15-R66, 15-R292 and 71-1-R136-BK. Cultivar 15-R55 had the least diseased appearance. Cultivars 15-R-148, 15-R287 and La Vega had disease-free root systems, while 15-R42, 15-R55 and 15-R66 contained plants with slight to moderate root infections. Cultivars 15-R55, 15-R180, 15-R189, and 71-1-R113 were moderately resistant to tolerant to bacterial blight.

Suggestions for Plant Breeding

The observations and results of this trial suggest that the rust resistant cultivars La Vega, Jamapa, 15-R55, 15-R66, 71-1-R136-BK, and 15-R292 are good candidates as parental material for breeding adaptability, multiple disease resistance, and high yielding potential into beans for tropical cultivation.

2. International Rust Resistance Trials

Only the findings (pages 10-11) on international rust resistance nurseries are given in this report. Interpretation of data and supporting evidence shall appear in the 1975 report.

d. Screening Red Beans for Adaptability and Disease Resistance

Purpose, Materials and Methods

Purpose

There is a great deal of consumer preference for red beans throughout Latin America. Also, some red bean cultivars produce the most attractive seed color and shape of the dry beans. However, most red beans have low yields, which is often the result of their suscpetibility to

diseases. Hence, it was decided to search within the red bean accessions for specific resistance, multiple resistance, and adaptability to lowland tropics.

Planting Method

Soil was treated with herbicides and insecticides before preparing the raised rows for sowing. Fertilizer, 5-10-10 NPK formulation, was applied in a band at the rate of 500 pounds per acre. The distance between the rows was 44 inches from center to center. Fifty fungicide treated seeds were planted in 10-foot long plots. Foliar insecticides were applied weekly. Applications of fungicides were made only when a disease threatened the destruction of the entire planting.

Results

Screening Trials

On October 10, 1970, 1,898 PI common bean accessions were planted at the MITA Isabela Farm, for seed increase and adaptability observations. During the growth period 84 red bean accessions were selected on the basis of plant growth, stand, and disease-free foliage. After harvest, 93 more red beans were selected on the basis of overall yield, seed color and shape. On September 28, 1971, the 177 selected red beans were planted in a field at MITA, Mayaguez. On November 6, 1972, the 84 field selected red beans were planted at the Isabela Farm. Two types of bacterial blight symptoms were recorded. The common bacterial blight lesions had a thin chlorotic band bordering the necrotic tissues, while tropical bacterial blight lesions had wide watersoaked margins which dried into necrotic tissue without any chlorotic periphery. Twenty of the selections were

free from both types of bacterial blight symptoms, 48 showed susceptible response with either type of symptom, and 15 were highly susceptible. Twenty-one selections did not have any CMV symptoms during the trial, while the rest were susceptible. The soil-borne diseases affected the stand and the vigor of the plants and hence their yields. The yield per row varied from 25-582 grams. Forty eight of the 93 accessions selected after the 1971 harvest were chosen for further screening in the field and inoculation tests in the greenhouse (Table 61).

Greenhouse Inoculation Test.--Ten seedlings from 36 selections were allowed to grow in two black plastic bags, 5 seedlings per container. The first set of five seedlings was inoculated with CBMV, and the second set with rust. After responses of the selections to these two diseases were recorded, the rust infected plants were treated with Plantvax. At early pod set stage, three weeks after the CBMV and rust inoculations, the plants were inoculated with a suspension of Xanthomonas. Table 62 summarizes these screening tests. Seven selections were rated as rust resistant, 21 selections remained free from CBMV, while three selections were free from common bacterial blight disease (Table 62).

On May 14, 1974, all 48 selections were planted at Las Gomez Field, MITA, Mayaguez. Only earliness, days to harvest, and total yield were recorded from this trial. The yield varied from 13-514 grams per selection. Six out of the 48 red beans segregated for seed color which indicates that during the 1971 planting at Isabela, at least 12.5 percent of the lines were cross pollinated.

Table 61.-Earliness and yield data of 48 red bean cultivars selected for inoculation in the greenhouse with CBMV, rust and the bacterial blight organism

PI No.	Earliness (days to harvest)	Yield (grams)	Remarks
150402	59	168	Shiny
310715	67	68	Red Shi
175266	63	106	Br., Pi. & Re
189406	62	46	Maroon, large. Selected for seed shape.
195373	69	75	D. red, shi.
203920	68	66	D. red shi., small
205359	61	46	D. maroon, medium
207159	59	89	Red mottle, Navy
207240	59	85	Red mottle, Kidney
226523	--	--	Shi., small
226880	62	169	Light red mottle, Kidney
282052	70	66	Dull red, small
304120	62	113	Shi., small
307770	77	225	Shi., med.
307774	62	120	Shi., med.
307819	62	84	Shi., med.
309849	67	166	Tan, light pink, med. shi.
310541	68	47	Shi., small
310560	67	36	D. red, Med., Shi.
310569	69	52	Shi., small
310577	67	154	Red Shi., small and med.
310756	59	104	Shi., med.

Table 61.-Cont.

PI No.	Earliness (days to harvest)	Yield (grams)	Remarks
310773	59	26	Dark red, shi.
310820	59	77	Dark, shi., small
310851	58	97	Dark, shi., small, Navy
310855	58	90	Shi., small
310859	58	59	Shi., small
310863	58	64	Shi., small
310864	59	69	Dark, shi., med.
310865	63	53	Shi., small
310869	65	82	Dark, shi., med., segregating
310870	63	82	Dark, shi., small
310871	62	47	Dark, shi., small
310901	72	111	Dark & light, shi., med.
310913	63	111	Dark, shi.
311187	71	75	Bayo, Navy, med.
313678	65	72	Light, mottle, Kidney
309835	70	96	Maroon, medium
309867	65	69	Dark, shi., med.
309875	65	109	Shi.
309886	73	126	Red, brown, shi.
310559	69	60	Shi., med.
310534	68	104	Dark, shi., small
310595	73	68	Light, shi., small
310673	65	108	Shi., med.

Table 61.-Cont.

PI No.	Earliness (days to harvest)	Yield (grams)	Remarks
310752	71	93	Segregating
310862	65	61	Dark, shi., small
311189	70	104	Shi.
311823	65	115	Light, shi.

Table 62.-Response of selected red beans to greenhouse inoculation with CBMV, rust and the bacterial blight organism

1974-N2A	1971-MYGZ	Rust			Bact.		Suggestions for future screening	
Row No.	Row. No.	Index	Percent	CBMV	Blt.	Rust	CBMV	Bact. Blt.
-74	R-1	3	90	--	S		+	
-75	R-3	3	50		S		+	
-76	R-4	2	90	--	S		+	
-77	R-5	1	80		S	+		
-78	R-7	1	60	--	S	+	+	
-80	R-9	5	90		--			+
-83	R-16	3	60	--	S		+	
-84	R-18	2	90	--	S	+	+	
-86	R-22	3	50	S	S			
-88	R-24	3	60	--	S		+	
-89	R-27	2	90	S	S			
-90	R-29	1	40	--	S	++	+	
-93	R-35	1	40	S	S	++		
-94	R-36	5	40	S	S			
-96	R-45	2	60	--	S		+	
-98	R-54	1	60	S	S	+		
-99	R-55	2	80	S	S	+	+	
-100	R-56	1	40	--	S	++	+	
-101	R-57	2	80	--	--	+	+	
-102	R-58	2	80	--	--	+		+
-103	R-59	1	40	S		++		
-104	R-61	5	40	S				
-105	R-62	1	80	S		+		

Table 62.-Cont.

1974-N2A Row No.	1971-MYGZ Row No.	Rust Index	Rust Percent	CBMV	Bact. Blt.	Suggestions for future screening: Rust	CBMV	Bact. Blt.
-106	R-63	1	60	--	S	+	+	
-108	R-68	1	60	--	S	+	+	
-109	R-72	1	10	--	S	+++	+	
-111	R-95	1	80	--	S	+	+	
-112	R-98	1	40	--	S	++		
-113	R-99	2	70	S	S	+		
-114	R-100	3	50	S	S			
-115	R-103	2	80	--	S		+	
-117	R-160	3	90	--	S		+	
-118	R-165	3	80	--	S		+	
-119	R-171	2	50	S	S			
-121	R-176	1	10	--	S	+++	+	
-122	R-177	5	80	--	S		+	

Diseases: Rust (Uromyces appendiculatus), Common Bean Mosaic Virus, Bacterial Blight (Xanthomonas sp.), P.M. = Powdery Mildew (Erysiphe polygoni).

Planted: 1 February 1974.

By 1974 the red bean screening trials had resulted in 28 selections on the basis of disease resistance and yield. From this stage on these selections are entered in replicated trials, both in field and greenhouse.

3. Yield Trial of Advanced Red Beans Lines Selected by the Edible Legume Program at Mayaguez (Red Bean Trial No. 3)

Purpose, Materials and Methods

The purpose of this trial was to compare yielding capacity and adaptability of seven advanced lines to the summer rainy conditions of the lowland tropics. These seven cultivars had been tested for rust resistance and adaptability to humid warm conditions since the summer of 1970. The highest yielding line was to be selected at this trial.

Cultivars.--Cultivars Ecuador-299 and Mexico-235 were used as multiple resistance standards. Cultivar Galana was included as local standard. Also included were cultivars Santa Ana, a high yielding, and early red bean from Nicaragua, and Gold Crop, a curly top disease and CBMV resistant, wax poded, white seeded, bush snap bean from Washington State. The seven local selections included were: 1) 15R-148 - shiny red seed, low vine, resistant to soil-borne diseases (especially Fusarium yellows) and rust; 2) 15R-149 - red seed, bush, resistant to rust and CBMV; 3) 15R-193 - dull brown seed, vine, resistant to CBMV, rust, and soil-borne diseases; 4) 15R-194 - shiny brown seed, semi-vine, resistant to CBMV, rust and soil-borne diseases, Selection 15R-194 - obtained from a plant with shiny seed coat in 15R-193; 5) 15R-224 - tan seed, bush, resistant to CBMV and moderately susceptible to rust; 6) 15R-277 - maroon and white seed, bush, rust resistant; and 7) 15R-287 - shiny pink seed,

semi-vine, rust resistant. All seven selections were susceptible to whitefly transmitted viruses, bacterial blight and angular leaf spot (Isariopsis griseola).

Methods.--The entire trial was treated exactly the same as Trials No. 1 and 2. The only difference here was that since the responses of the seven selections to diseases were already known, no new set of data on diseases was recorded.

Results

Germination

In this trial the germination percentage of Ecuador-299 dropped from around 55% down to 45%. With the exception of Ecuador-299, all the cultivars with low seed germination (between 24 to 45%) were bush types. In this test again Santa Ana had the lowest germination. The semi-vine and vine types germinated from 65 to 80%. It is interesting to note that both Mexico-235 and 15R-148 are highly susceptible to CBMV, but possess a high degree of field resistance to soil-borne diseases. The 80 and 75% stand at 20 days after sowing reflects the quality of their seeds and seedlings for resistance to soil-borne diseases, which in this trial were caused mainly by Rhizoctonia solani and Sclerotium rolfsii.

Yield

Neither Ecuador-299 nor Mexico-235 flowered during this trial. Rhizoctonia root rot and stem canker, southern blight and ashy stem blight caused plant mortality in all bush types. Bacterial blight was uniformly spread and rust was non-significant. The toll taken

by root rot diseases among the bush types was reflected in their yields. Gold Crop was severely affected by diseases. Selection 15R-148 in spite of CBMV infections outyielded other selections. Selections 15R-193 and 15R-194 grew vigorously but had poor to fair pod set. Both selections yield heavily when planted during the cool dry season.

Summary of Results

Selection 15R-148 is a rust resistant, CBMV tolerant, soil-borne disease resistant, daylength-insensitive cultivar with dark red, Mexican type, dry beans. This cultivar is an important candidate for breeding red beans adaptable to tropical lowlands.

Selection of Bush Beans for Cultivation in Puerto Rico

Background

During the Fall of 1969, Dr. M. Rico-Ballester (see Personnel) indicated that there was a need for bush beans adaptable to cultivation in the lowlands of Puerto Rico. The recognition of this need initiated cooperative research. The high price of beans in the past year has made commercial cultivation of beans on the Island a stronger possibility and hence has provided new impetus to our work.

Selection of Cultivars, 1969-70

Seeds of 136 Plant Introduction (P.I.) accessions selected as bush beans in an earlier planting were cultivated near Mayaguez during the Fall of 1969. Selected seeds from this planting plus 14 commercial cultivars were grown at Isabela during January-February, 1970.

Golden yellow mosaic (GYM), Rhynchosia mosaic (RM) and angular leaf spots (ALS) (*Isariopsis griseola*) were the main diseases during these trials. Selected seeds from the latter planting were used in a summer rainy season planting (June-September, 1970) at Lajas.

1970 Lajas Trial

Single rows of selected cultivars were planted during 27-28 June 1970. Each selection consisted of 50 seeds. Rhynchosia mosaic was the most prevalent disease followed by Phyllosticta leaf spot (P. phaseolina) Golden yellow mosaic (GYM) occurred sparsely, while common bean mosaic virus (CBMV) incidence was moderate. White mold (Sclerotinia sclerotiorum) was scattered throughout the field.

Chlorosis.--Some bean cultivars when grown in Lajas or Fortuna Substations, develop a leaf chlorosis which is suggestive of a virus disease. The chlorotic leaves develop a hard and brittle appearance. These symptoms could also be a response to micronutrient deficiency or to toxic materials in the soil.

Whitefly transmitted viruses (WFTV).--The fences nearby the bean trial at Lajas were covered with diseased Rhynchosia minima, and the incidence of RM among the experimental beans was very high. However, a number of cultivars were free from WFTV diseases. Seventeen of these cultivars have remained free from WFTV diseases in the five trials conducted to date. These were: Lajas row-4, R-12, R-14, R-36, R-39, R-40, R-41, R-51, R-52, R-57, R-88, R-91, R-101, R-117, R-141, and R-144. Further tests are required to ascertain the extent of field resistance in these selections.

Adaptability.--Even though RM and Phyllosticta leaf spot were prevalent in the plot, and heat and rains made conditions unfavorable for pod set, a number of selections maintained a good stand and yielded well. Twenty of the selections were free from diseases during this trial.

Dr. Rico-Ballester made further selections on the basis of yield, plant habit and seed characteristics. These final selections were planted at Lajas again on December 19, 1972.

1972 Lajas Trial

On December 19, 1972, the selections from the 1970 summer rainy season were planted for seed increase. At harvest, further selections were made. These were based on yield and horticultural characteristics, such as high and concentrated pod position, tight formation of branches, and stiff, upright stems. Selections made at this trial were planted at Lajas on January of 1974.

1974 Lajas Trial

One hundred seeds of each selection were planted in two rows, 18 inches apart, 50 seeds per row. Each pair of rows was placed at 5 feet from the adjacent pair. Ground irrigation was provided during the growth period. The trial was sown on January 15-16, 1974.

Diseases.--Both rust and common bean mosaic virus (CBMV) were prevalent during this period (dry season, November to March) at Lajas. Natural field infection by rust caused defoliation of some susceptible lines 45 days after planting. The following selections were highly resistant to rust: Lajas Row No. 1, 4, 11, 31, 34, 36, 48, 58, 59, 97, 99, 101 and 144. These were also a number of selections with moderately resistant, grade "2" reaction.

Common bean mosaic virus incidence was high among the selections. However, either tolerant response or late infection of the plants made it difficult to designate clear cut disease responses in a number of

selections. The following selections were free of CBMV symptoms: Lajas Row No. 17-B, 26-B, 42, 53, 57, 67, 72-A, 88, 118, 126, 147 and 176. The CBMV-free selections will be screened in the greenhouse to ascertain their resistance.

Even though the Lajas climate at this period is very dry, a number of selections had bacterial blight (Xanthomonas sp.). An interesting aspect of this trial was the low incidence of the WFTV such as RM and GYM. Most likely the reason for this was destruction of the infected R. minima plants near the plots, and the application of contact insecticides.

Infestation with leaf miner (Liriomyza sativae) was severe. The flies seemed to prefer some selections to others as selections lightly colonized by the insect were adjacent to severely infested ones.

Agronomic Characteristics.--Two sets of agronomic data were gathered. The first set was obtained at flowering and full green pod stages, and the second was prepared at harvest time, and afterwards in the seed room.

Flowering and Earliness.--Line selections at 50% stages of open flowers were rated as: Very Early (VE), flowered at 18 to 21 days after sowing; Early (E), at 22 to 25 days; Intermediate (I), at 26 to 30 days; Late (L), at 31 to 35 days; and Very Late (VL), at 36 to 40 days. Thirty of the selections were in VE and E categories.

Lodging.--Plants standing upright were given an index of "1" for lodging and those which were prostrate on the ground received an index of "5". The lodging index was an average of grade for the appearance

of an entire selection. The grades between 1 and 5 indicate the intermediate conditions. The upright habit of the plants reflected the stiffness of their stems and a well formed root system that sustained the weight of the plant and its pods.

High Pod Position.--The moist, warm and pathogen-infested soil of the tropics provides an excellent inoculum source for the bean pods that rest on it. *Rhizoctonia solani*, *Sclerotium rolfsii*, *Sclerotinia sclerotiorum* and *Fusarium* rot any pod that touches the infested soil. Hence, only a bean plant that produces its pods off the ground can retain its yield at harvest. A good deal of attention was given in selecting plants with high-pod habit.

Snap Bean.--Ten of the selections had stringless full pods. These selections could become good candidates as fresh market snap beans. The following selections were snap beans: Lajas Row No. 14, 42, 52, 53, 54, 126 128, 143, 146 and 147. The selection Lajas Row No. 54 could become an excellent candidate for fresh market snap beans. One selection (Lajas Row No. 77) was wax bean.

Plant Maturity and Pod Ripening.--Often in the same row the stem and pods of some plants dry at the same time, while other plants have dry pods but green stems and fresh roots. Field observations have shown that the reason for the dry stems of the former group is generally rotted root systems, but in the latter group the root systems had either escaped diseases or are more tolerant. However, uniformly dry plants are mode adaptable to mechanical harvest. The two groups were separated at harvest. At harvest plants were also selected for erectness, high pod location, concentrated pod set and high yield.

Selections.--Based on upright, high pod position, earliness, yield and field response to diseases, 19 lines were selected as outstanding. One hundred thirty-five selections enumerated were planted in a heavily pathogen-infested plot at Isabela during the rainy season of July-September, 1974.

Isabela Trial, July-September, 1974

There were variable amounts of seed per selection. Hence, planting of each replication was repeated in replicates of 30 seeds each, untill all seeds in each selection were sown. The number of replicates per selection varied from 1 to 5 representing 30 to 150 seeds, respectively. Replicates 1 and 2 were sown on 31 July and replicates 3, 4 and 5 on 10 August 1974. None of the seeds were treated with fungicides. Seeds were sown in a field that was heavily infested with the causal agents of diseases such as Rhizoctonia root rot, web blight, bacterial blight, and ashy stem blight. The warm rainy season provided excellent conditions for screening against these diseases.

Diseases

I. Rhizoctonia Root Rot (RRR).--The severe and uniform incidence of RRR in this trial provided ample opportunities for examining various components of the host-parasite interaction in the field, and hence drawing a fairly reliable conclusion on field tolerance of some of these selections. Four recordings of RRR incidence were made at 20, 45, 63 and 85 days after sowing. During the first 2 weeks after emergence seedling mortality was high. Generally, disease severity decreased with age of the plants. In some cases after the initial seedling mortality the

remaining mature plants, such as those in Row 106, displayed resistance to the disease. Some selections were totally resistant, e.g., four replicates of Row 102 and five replicates of Row 113. In many a susceptible plant, the whole root systems up to 1/2 inch below the soil level was completely rotted. However, some of these plants were surviving due to adventitious roots that grew our from the stem. The high humidity allowed these adventitious roots to grow until reaching the soil. In spite of heavy rains, and the susceptibility to RRR, many selections retained ample and viable root systems. When screening beans for resistance to RRR, tolerance to infection is an important factor. For example, plants of Row 76 developed a "strong and deep" root system, even though most of its roots had Rhizoctonia lesions. Selections having RRR resistance will be further tested both in the field and in the greenhouse. All selections were susceptible to web blight caused by the sporidial stage of Thanatephorus cucumeris.

The formation of rhizobial nodules on roots of 10 selections was not anticipated, especially under warm and humid soil conditions.

II. Bacterial Blight and Stem Canker (B. Blt.).--Most selections were relatively free from bacterial blight before flowering. Between flowering and pod set the intensity of disease expression increased and by the time pods were turning color some lines were totally defoliated. Plants in some selections seemed to become more resitant as they matured. The apparent mature plant resistance could be due to greater leaf production by the resistant plants in the row. Twelve of the 17 selections that retained 40 to 75 percent of the foliage

until 85 days old, were tolerant to bacterial blight. Seven of the "leafy" selections had field tolerance to both RRR and B. Blt. Of the five remaining selections, four had mature plant tolerance, while the fifth one retained its leaves in spite of bacterial blight disease.

Retention of the leaves was not associated with rust resistance. It was due to the low intensity of rust incidence during the summer rainy season.

III. Ashy Stem Blight.--Ashy stem blight caused by Macrophomina phaseoli was prevalent in the field. However, disease incidence was not uniform throughout the field. Hence, it was difficult to assign resistance with certainty.

IV. Anthracnose.--Selections from lines R-144 and R-146 were susceptible to anthracnose. This was one of the few occasions that bean anthracnose was encountered during the warm season in the tropical lowlands. These selected lines should be highly susceptible to a race of the anthracnose fungus that is tolerant to high temperatures.

V. Whitefly Transmitted Viruses.--The incidence of RM and GYM was low in the plot, but the disease was uniformly present.

VI. White Mold.--Mycelial tufts of Sclerotinia sclerotiorum affected leaves and pods of a few selections in scattered spots in the field.

Pathogen-Infected Seed

A bean cultivar may yield well, but when harvested and threshed, as high as 60 to 80 percent of the seeds could be affected by bacterial and fungal lesions. Under warm and moist conditions and without any chemical

treatment, high seed infection is of common occurrence. Any bean cultivar that maintains during the rainy season, relatively disease-free seeds up to harvest, is worth selecting and studying. The data does not suggest any relationship between disease-free seed characteristics and resistance to ashy stem blight or bacterial blight.

Agronomic Characteristics and Yield

Many bush selections had stiff, upright stems. The majority of these matured early (65 days after sowing). The average yield of 100 grams per replication was considered satisfactory for the growing conditions. The majority of the seeds were large, weighing 30 grams per 100 seeds. Some of the selections had the undesirable characteristic of seeds with open testa and protruding cotyledons.

Final Selections

Advanced selections were based on average yield per replicate, weight per 100 seeds, seed shape and color. These selections were matched with disease resistance performance in the field, and desirable agronomic characteristics of the selected lines recorded both at Lajas and Mayaguez. Table 63 provides the summary of data on advanced selected lines at Mayaguez. Seven of the seventeen selections were independently selected by both Rico and Vakili.

The 1975 fall planting shall provide the final candidates for release as locally adaptable bush beans.

Table 63.-Selected bush beans with best agronomic and disease resistance characteristics

Selection		Habit 2/	Seed color 3/	Grams/ 100 seeds	Days to harvest	Foliage at 85 days Percent	CBMV	WFTV 1969-70 RM	WFTV 1969-70 GYM	B Blt	RRR	Rust	Selection
R-17-B	1/	B	Maroon	48	65	---	R?	--	S	---	---	R	* 3/
R-40	1/	B	Cream-Purple Pinto	39	73	---	MS	--	--	MS	S	S	*
R-56		B	Tan	20	73	50	--	S	--	R	R	---	
R-56-BK-B		B	Tan	20	73	50	--	S	--	R	R	---	**
R-69-BK-B		B	Tan	18	65	40	--	S	S	R	R	---	**
R-72-A-BK-1	1/	B	Cream-Purple Pinto	30	65	5	NI	--	--	--	R	---	*
R-72-A-BK-2	1/	B	Pinto	31	65	40	NI	--	--	--	R	---	*
R-88-BK-B		B	Maroon	39	73	---	NI	--	--	--	---	R	*
R-91-BK-A	1/	B	White	20	73	70	--	S	--	R	R	---	***
R-108-BK-A	1/	SV	Drab	18	73	15	S	--	--	S	R	S	*
R-109-Sel		B	Brown	18	86	--	R	--	--	--	R	---	*
R-109-BK-A		SV	Brown	18	86	50	R	--	--	R	R	---	***
R-117-BK		B	Black	31	65	50	--	--	--	R	R	---	**
R-128-BK-A		B	Yellow	29	65	50	--	--	S	--	---	---	*
R-135		B	Tan	23	85	30	R	--	S	--	R	---	*
R-148-B-BK		SV	Tan-Purple	56	73	75	--	S	S	R	---	---	***
R-176-BK	1/	B	Pinto-Purple Pinto	28	85	50	NI	--	--	R	R	---	***

1/ Independently selected by Rico and Vakili.
2/ Habit - B = Bush, SV = Semi-vine
3/ * = A desirable cultivar, ** = Better than average, of high performance, and *** = An excellent cultivar.

G. Cowpea Disease Resistance Trials

a. Horticultural (Yardlong) Cultivars from Trinidad

Background

Yardlong beans (Vigna unguiculata var. sesquipedalis) are the sna beans of the humid tropics. Seeds are sown at the start of the rainy season, generally during the month of May, and the long green pods are harvested from July to November. At the market places, pods are sold in bundles of 10 or 20. Green pods are cut into sections and cooked as fresh vegetable.

Field observations in tropical America by Vakili indicated that yardlong bushes were susceptible to cowpea mosaic virus, bacterial blight and canker, Cercospora leaf spot, target spot, Choanephora po blight, and web blight diseases. If yardlongs were planted under irrigation during the dry season, then powdery mildew causes severe defoliation of the plants. Despite the high degree of susceptibility, yardlong cultivation generally yields well and brings in a good price.

In 1972 the Edible Legume Project at MITA began collecting yardlong cultivars and observing them for disease resistance and agronomic characteristics. It was observed that yardlong cultivars varied greatly in their pod length, but had the following common characteristics: bean-shaped seed; few seeds distributed in the length of the pod; and reduction of fiberous tissues in the pod, which generally resulted in shrinkage when pods ripened.

Yardlong is a vegetable crop grown in Trinidad, and hence an object of research interest in that country. In July 1973, Dr. T. U. Ferguson,

Agronomist, University of the West Indies, sent to MITA 76 lines of *Vigna unguiculata* which included a number of yardlong types. These accessions were subjected to greenhouse inoculations, and preliminary field observations during the summer of 1974.

Results of Greenhouse Inoculations

Four seedlings per accession were inoculated with *Xanthomonas vignicola* (Xv), and another four with cowpea mosaic virus (CPMV).

Xanthomonas vignicola Inoculation.--Seedlings at the third trifoliate leaf stage were inoculated by placing a droplet of turbid bacterial suspension in the first trifoliate leaf node and then puncturing the stem (through the bacterial suspension) with a sterile needle. Inoculated seedlings were placed in a humidity chamber for a week. The response of seedlings to inoculation was recorded (Table 64). All accessions with highly susceptible (HS) response died within 2 weeks of inoculation. The susceptible (S) accessions survived inoculation but displayed long stem cankers. None of the Trinidad accessions was resistant to bacterial blight.

Cowpea Mosaic Virus Inoculation.--Seedlings were inoculated at the primary leaf stage by rubbing the leaves dusted with carborundum with forefingers dipped into the leaf extract from CPMV source. Fourteen days later, inoculated seedlings were rated for CPMV response. Twelve accessions were highly susceptible (HS). Growth of these plants was severely retarded, some were malformed, and some seedlings were dying. Forty-three accessions were susceptible (S). Susceptible plants displayed mosaic and malformation of leaf tissues, but very slight reduction

Table 64.-Results of greenhouse inoculations of *Vigna unguiculata* var. seedlings (raised from seed received from the University of the West Indies, Trinidad) with *Xanthomonas vignicola* (Xv) and Cowpea mosaic virus (CPMV).

Accession (FES-PR-No.)	Response to Inoculation	
	Xv	CPMV
2883	--	--
2884	--	--
2885	--	--
2886	--	--
2887	S	HS
2889	HS	S
2890	HS	MS
2891	HS	MS
2892	HS	S
2893	HS	S
2894	HS	MS
2895	HS	S
2896	HS	S
2897	HS	S
2898	HS	S
2899	HS	S
2900	HS	S
2901	HS	S
2902	HS	S
2903	GS	S
2904	HS	S
2905	HS	S
2906	HS	S
2907	HS	S
2908	S	S
2910	HS	HS
2911	S	MS
2912	HS	S
2913	S	S
2914	HS	S
2915	HS	HS
2916	HS	HS
2917	HS	HS
2918	--	--
2919	HS	S
2920	--	--
2921	--	--
2922	S	S
2923	HS	S
2924	S	S
2925	HS	S
2926	HS	--
2927	HS	

Table 64.-Cont.

Accession (FES-PR-No.)	Response to Inoculation	
	Xv	CPMV
2928	HS	S
2929	HS	HS
2930	HS	S
2931	S	S
2932	HS	MS
2933	HS	S
2934	HS	S
2935	HS	S
2936	HS	S
2937	HS	S
2938	HS	S
2939	HS	HS
2940	HS	S
2941	--	--
2942	S	S
2943	HS	HS
2944	HS	MS
2945	S	S
2946	S	HS
2947	HS	S
2948	--	--
2949	HS	S
2950	--	--
2873	--	--
2874	HS	MS
2875	--	--
2876	HS	MS
2877	HS	MS
2878	S	S
2879	HS	HS
2880	--	--
2881	HS	S
2882	S	S
Standard	HS	HS
Standard	HS	S

in growth. Nine accessions which were moderately susceptible (MS), displayed detectable leaf mosaic, but normal growth. There were no resistant plants among the Trinidad accessions

Results of Field Observations

Five seeds of each accession were planted in a single hill. Each hill was 4 feet (121 cm) away from the next hill in both directions. Planting was done on April 15, 1974. Table 65 provides field observations recorded 50 days after sowing. Only accessions which had passed flowering stage were rated. This indicates that accessions not mentioned in Table 65 were late flowering. A few accessions had mature pods at 51 days indicating early maturity. Shrunken pods suggested low fiber content in the pod tissues. Some cultivars were infected with Erysiphe polygoni, the causal organism of powdery mildew. Table 66 presents the total yield per accession. Even though five seeds were sown per accession, the yield does not include the seeds of five plants. In many cases only one survived, or the surviving plants were badly diseased. The days to harvest represent the average days between the first and the last day. Table 67 provides some of the components of yield recorded at harvest. The information is based on the averages of ten pods. The length of the pods were recorded on dry pods harvested. The dry pod seemed to be slightly shorter than the green fresh pod. However, the data on pod length should be relatively the same for all accessions. The length of pod which contained a single seed seemed to be one of the factors indicative of yardlong characteristics. Table 68 divides the accessions according to pod lengths, while Table 69 provides the ranges

Table 65.-Field observation on some Trinidad Yardlongs (*V. unguiculata* var. *sesquipedalis*) 51 days after sowing

Accession (FES-PR-No.)	Pod characteristic	Pod Length (cm)	Pod set	Remarks
2882	YL	Med.	GP	
2889	YL	Long	GP	PM:S
2876	YL	Med.	GP	PM:S
2896	YL	Med.	GP	Pu. Pod
2914	YL	Long	GP	
2915	YL	Med.	GP	
2937	YL	Med.	DP	PM:S
2941	YL	Med.	GP	
2946	YL	Med.	GP	
2947	YL	Med.	GP	
2948	YL	Long	GP	PM:S, Mid.
2898	YL-type	Short	GP	Red pod
2899	YL-type	Short	GP	Red pod
2873	YL-type	Med.	GP	Early
2880	YL-type	Med.	DP	Early
2902	YL-type	Short	GP	
2919	YL-type	Short	DP	Shrunken pod
2920	YL-type	Short	GP	
2921	YL-type	Short	GP	
2923	YL-type	Short	GP	Pu. pod, PM:S
2933	YL-type	Short	GP	PM:S
2935	YL-type	Short	DP	Shrunken pod
2945	YL-type	Short	GP	
2895	CP	Short	GP	
2900	CP	Short	GP	PM:S
2903	CP	Short	DP	Shrunken pod
2911			Flower	Late
2927			Flower	B. Blt.:S, late

Abbreviations:

YL = yardlong
CP = cowpea
DP = dry pod
GP = green pod
veg. = vegetative growth

Pod length:
Short - 10-25 cm.
Medium - 25.1-50 cm.
Long - 50.1-100 cm.

Table 66.-Yield of dry seeds from Trinidad Yardlong (*V. unguiculata* var. *sesquipedalis*) accessions (15 May - 23 July 1974)

Accession (FES-PR-No.)	Total[1/] yield (grams)	Days[2/] to harvest
2879	137.9	94
2873	7.8	94
2875	24.2	98
2876	219.5	98
2877	129.9	94
2879	136.0	98
2880	77.3	98
2881	144.6	85
2882	93.2	97
2883	275.0	85
2884	144.9	94
2887	87.5	99
2889	159.2	98
2890	105.8	85
2891	84.8	98
2892	9.3	94
2895	195.5	90
2896	259.7	90
2897	221.7	90
2898	185.6	94
2899	236.6	90
2900	177.5	90
2901	167.8	94
2902	33.9	90
2903	264.3	85
2904	211.0	85
2905	264.2	94
2907	167.0	88
2908	329.2	94
2910	37.7	98
2911	227.2	90
2912	201.2	90
2913	205.7	94
2914	88.6	85
2915	275.6	80
2916	323.5	90
2917	252.3	85
2919	233.9	85
2920	41.5	90
2921	224.3	94
2922	171.6	90
2923	11.9	82
2924	225.5	90
2925	265.0	95

Table 66.-Cont.

Accession (FES-PR-No.)	Total[1/] yield (grams)	Days[2/] to harvest
2927	164.7	82
2928	142.3	94
2929	183.2	85
2930	306.0	90
2931	161.7	90
2932	196.4	90
2933	122.5	85
2934	147.0	90
2937	133.3	85
2939	123.6	85
2940	174.0	88
2941	262.0	90
2943	186.0	85
2944	154.3	90
2945	197.0	98
2946	45.4	90
2947	29.0	85
2948	62.9	94
2949	177.5	90

1/ Five seeds were planted per hill.

2/ Average of several harvests.

Table 67.-Yield components of Trinidad Yardlong (*V. unguiculata* var. *sesquipedalis*) accessions

Accession (FES-PR-No.)	Average of ten pods		
	Pod length cm.	Number of seeds/pod	Pod length (cm)/seed
2870	27.3	16.6	1.64
2873	19.9	9.6	2.07
2876	26.9	15.4	1.75
2877	17.0	15.7	1.08
2879	19.0	12.8	1.49
2880	27.5	14.4	1.91
2881	55.4	17.8	3.11
2882	32.8	11.0	3.15
2883	33.3	17.3	1.92
2884	95.9	18,5	5.18
2889	53.0	18.7	2.83
2890	53.6	16.5	3.25
2892	26.5	15.5	1.71
2895	19.8	12.6	1.57
2896	20.1	16.4	1.23
2897	26.8	14.8	1.81
2898	30.1	19.2	1.57
2899	29.3	18.3	1.60
2900	18.5	14.4	1.28
2901	21.5	15.3	1.41
2902	20.3	14.5	1.40
2903	19.2	14.6	1.32
2904	18.8	14.3	1.31
2906	18.4	14.2	1.30
2907	23.8	14.9	1.59
2908	28.8	17.7	1.62
2911	25.7	16.0	1.60
2913	24.5	16.4	1.49
2914	51.9	13.8	3.77
2915	31.2	17.5	1.81
2916	32.3	16.5	1.95
2917	30.4	18.3	1.66
2919	23.4	15.9	1.47
2920	17.7	13.8	1.28
2921	20.3	14.7	1.38
2922	24.5	18.9	1.29
2923	17.7	14.3	1.23
2924	20.7	15.7	1.32
2925	31.5	17.2	1.83
2927	20.6	16.3	1.26
2928	17.5	14.0	1.25
2929	18.4	14.0	1.31
2930	16.6	14.8	1.12

Table 67.-Cont.

Accession (FES-PR-No.)	Average of ten pods		
	Pod length cm.	Number of seeds/pod	Pod length (cm)/seed
2931	17.7	13.4	1.32
2932	17.8	17.1	1.04
2933	18.7	12.6	1.48
2934	20.5	15.9	1.29
2935	18.4	14.1	1.30
2937	33.0	17.8	1.85
2939	38.6	18.9	2.04
2940	44.4	19.5	2.27
2941	37.2	16.2	2.29
2943	49.9	16.7	2.99
2944	21.2	16.5	1.28
2945	22.6	17.0	1.33
2946	28.0	10.2	2.75
2947	27.2	15.3	1.77
2948 1/	48.1	8.1	5.94

1/ Two types of pod lengths in this accession.

Table 68.-Grouping of Trinidad yardlong (*V. unguiculata* var. *sesquipedalis*) accessions according to pod length (centimeters)

10-14.99	15-19.99	20-24.99	25-29.99	30-34.99	35-39.99	40-49.99	50-59.99	60-69.99	70-79.99	80-89.99	90-100
		2896		2882	2939	2940	2881				2884
			2870	2883	2941	2943	2889				2948
	2873	2901	2876			2948	2890				
	2877	2902		2898							
	2879	2907	2880				2914				
	2895	2913	2892	2915							
	2900	2919	2897	2916							
	2903	2921	2899	2917							
	2904	2922	2908	2925							
	2906	2924	2911	2937							
	2920	2927	2946								
	2923	2934	2947								
	2928	2944									
	2929	2945									
	2930										
	2931										
	2932										
	2933										
	2935										

Table 69.-Grouping of Trinidad Yardlong (*Vigna unguiculata* var. *sesquipedalis*) accessions according to ranges of pod length (cm.) per seed

1.00-1.75	1.76-2.75	2.76-4.00	4.01-5.00	5.01-6.00
2870	2873	2881		2884
	2880	2882		2948
2876	2883	2889		
2877	2897	2890		
2879	2915	2914		
2895	2916	2943		
2892	2937			
2896	2939			
2898	2940			
2899	2941			
2900	2946			
2901				
2902				
2903				
2904				
2906				
2907				
2908				
2911				
2913				
2917				
2919				
2920				
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2923				
2924				
2925				
2927				
2928				
2929				
2930				
2931				
2932				
2933				
2935				
2944				
2945				
2947				

of pod length for each seed. As Table 68 shows, there were no accessions which had pod lengths of between 60 to 90 cm. Many yardlong types had pod lengths of between 30 to 60 cm. Pod lengths lower than 30 cm belong generally to the cowpea types. Also, as Table 69 shows, there were no accessions which fell within the range of one seed per 4 to 5 cm of the pod length.

Selected yardlong accessions from the Trinidad group will be subjected to further studies and will be compared with other yardlong accessions.

b. International Cowpea Disease Nursery (ICDN)

One hundred cowpea (Vigna unguiculata) accessions selected for multiple disease resistance by Dr. Robert Williams, Plant Pathologist, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, were received 3 June 1974. Also included in the ICDN trial were four standard susceptible cultivars. The trials included two replications. The first replicate was planted at Mayaguez on 6 May 1974, while the second replication was planted at Isabela on 19 June 1974. The plantings were done according to the plot layout suggested by Dr. Williams. Two locally selected cowpea lines: 10-R61, resistant to cowpea mosaic virus (CPMV), powdery mildew and Cercospora leaf spot; and 10-R65, susceptible to CPMV, powdery mildew and Cercospora leaf spot were used as local standards. Overhead irrigation was applied whenever sufficient rains did not fall within three days.

ICDN Trial at Mayaguez

Diseases

I. Cowpea Mosaic Virus (CPMV).--Cowpea mosaic virus culture #X-44 from the Agricultural Experiment Station, Río Piedras, was used for inoculation. Type culture was increased on cowpea seedlings in the greenhouse prior to field inoculation. Field inoculation was done by spraying seedlings at a distance of 15 to 20 cm with a pneumatic spray gun, 50 psi nozzle pressure. The inoculum consisted of leaf juice from the CPMV diseased greenhouse plants. The IITA cowpea entries were inoculated twice, on 5 July and on 19 July 1974.

Recording Disease Incidence.--During the recordings performed on 17 and 24 July a number of lines showed more than one type of response. However, by 5 August, or one month after the first inoculation, all plants in each row had the same response. The local CPMV resistant standard cultivar 10-R61 had a few vine type hybrids which invariably had SS or MS type response. Of the 104 lines tested 13 were resistant and two were moderately resistant against CPMV.

II. Bacterial Blight (Xanthomonas sp.).--A local bacterial isolate culture #113 of Xanthomonas, was increased on Nutrient Agar for 48 hours for preparing a turbid suspension. Field inoculation was accomplished by sand blasting the plants at 50 psi nozzle pressure at a distance of 3 ft, before spraying with the turbid (1×10^7) bacterial suspension. Plants were inoculated at flowering. The same inoculation was repeated a week later, in order to assure uniform infection. The response of the cultivars to inoculation was recorded 2 weeks after the first inoculation. Seven of the IITA entries were free from bacterial blight lesions.

III. Rhizoctonia stem rot and web blight.--Rhizoctonia stem rot, and especially web blight, were prevalent in both fields. At Isabela, sporidial infection became so severe that some cultivars were defoliated before mycelial infection could advance. At both locations the entry IITA-96 seemed to possess field tolerance to this disease.

IV. Others.--Powdery mildew (PM), Cercospora leaf spot (CLS), and target spot (TS) were present in both fields. The cultivars that had powdery mildew (Erysiphe polygoni) should be considered highly susceptible to this disease, since powdery mildew is not a rainy season disease. Cercospora leaf spot was mostly caused by C. cruenta. Natural infection by CLS occurred on nine out of twelve replicates of the standard susceptible local cultivar, 10-F65, while the twelve replicates of the resistant local standard, 10-R61, were free from the disease. This indicates that the CLS-free cultivars were most likely resistant to this disease. A few entries were affected by target spot (Corynespora cassiicola).

At Isabela the whole plot was severely infested by the cowpea pod weevil (Chalcodermus ebeninus). About 90 to 95 percent of the seeds were attacked. No tolerance to pod borer was detected during the general field observation.

H. Release of Disease Resistant Bean Lines

At the beginning of 1974 a number of disease resistant bean lines had reached the level of selection that justified their release as sources of multiple disease resistance. Three of these lines are resistant to common bean mosaic virus, Puerto Rico cowpea mosaic virus,

a strain of cucumber mosaic virus, rust and Fusarium wilt. Fourteen other lines were released as sources of resistance to rust. Eight lines from this group were also resistant to common bean mosaic virus. Detailed descriptions of these materials are given as Appendix I (Section H).

3. Research Design

No significant modifications were made in the research design prior to the current reporting period.

E. DISSEMINATION AND UTILIZATION OF RESEARCH RESULTS

Efforts to disseminate the results of investigations conducted under the Project were made via (1) publications (Appendix II - Section H), (2) organization of a grain legume disease workshop, (3) participation in national workshops and meetings, and visits to collaborators and prospective collaborators in foreign countries and the United States (Appendix III - Section H), (4) visits from interested scientists from abroad and from the United States (Appendix IV - Section H), (5) correspondence, and (6) distribution of seed requested by researchers (Appendix V - Section H).

A list of statements that identify use of materials and information produced by the Project appears as Appendix VI (Section H).

F. STATEMENT OF EXPENDITURES AND OBLIGATIONS AND CONTRACTOR RESOURCES.

Line Item	Total Budget Amount 4/1/74-3/31/75	To Date 4/1/74-12/31/74	Estimated 1/1/75 3/31/75	Total Actual and Estimated
1. Salaries	$167,748.00	$ 86,452.12	$ 81,295.88	$167,748.00
2. Honoraria	5,000.00	840.18	4,159.82	5,000.00
3. Travel	24,411.00	6,591.76	17,819.24	24,411.00
4. Equipment & Supplies	50,999.00	23,389.28	27,609.72	50,999.00
5. Publications	2,000.00	2,000.00	-	2,000.00
6. Other Direct Costs	7,954.00	-	7,954.00	7,954.00
7. Indirect Costs (Overhead)	67,296.00	39,767.96	27,528.04	67,296.00
Total	$325,408.00	$159,041.30	$166,366.70	$325,408.00

G. WORK PLAN AND BUDGET FORECAST FOR COMING YEAR

Virology

1. Continue the survey of virus diseases of legumes in Puerto Rico and abroad utilizing personal observations as well as contacts established with investigators in other areas.
2. Properly characterize such viruses on the basis of transmissibility (artificial, seed and insects), serology, differentials, host range, vector-virus relations and cross protection. New legume diseases such as the mosaic of *Poinsettia geniculata* = *Euphorbia prunifolia* will be studied in relation to its natural vector (*Bemisia tabaci* race *sidae*) and host range as well from the standpoint of their transmissibility by mechanical means. Attempts will be made to visualize the causal agents of the rugaceous diseases through the electron microscope.
3. Establish and operate an electron microscopy laboratory. This unit is to be used mostly for identifying ultramicroscopic entities causing diseases of legumes.
4. Attempt to develop methods for the efficient transmission by mechanical means of the local rugaceous disease agents.

Control of Fungus and Bacterial Diseases

1. Conduct field trials on the chemical control of bacterial blight of bean.
2. Conduct experiments (wet and dry season) on the chemical control of bean rust.

3. Screen fungicides *in vitro* for effectiveness against the cowpea foliar pathogens *Corynespora cassiicola* and *Cercospora cruenta*.
4. Determine the etiology of a newly discovered stem disease of cowpea; study the biology and control of the causal agent.
5. Identify, through the use of differential varieties, the physiologic races of *Uromyces phaseoli* var. *typica* present in Puerto Rico.

Entomology

1. Conduct field tests to evaluate chemicals for control of insects, particularly, leafhoppers, leafminers and cowpea weevils.
2. Conduct field tests to evaluate insect attack and damage on selected varieties of bean and cowpea.
3. Conduct field plot, shadehouse and laboratory studies to provide information on:
   (a) the biology and natural enemy complex of the leafminer *Liriomyza sativae*
   (b) to study host plant resistance to *L. sativae* in selected varieties of bean and cowpea.

Screening and Breeding for Resistance

1. Continue screening to advance work on disease resistance and development of lines with the highest grade of resistance to:
   (a) *Bean* - Rhynchosia mosaic, bean common mosaic, cucumber mosaic, golden mosaic, *Fusarium* wilt and other soil-borne diseases. Large collections of new materials from other programs (USDA, IITA, CIAT, Trinidad, etc.) are available to continue the screening process.

(b) Cowpea - cowpea mosaic virus, bacterial blight, *Cercospora* and *Corynespora* leaf spots, and powdery mildew.

2. Conduct further tests with selected material to obtain higher grades of field resistance to the more serious insect pests and diseases.
3. Continue breeding for multiple disease resistance. Controlled conditions will be utilized to increase the percentage of seed set by hand. Intensive use will be made of field pollination by carpenter bees.
4. Conduct preliminary field trials at 6 locations in Puerto Rico.
5. Continue maintenance and expansion of the germ plasm bank at the Mayaguez Institute of Tropical Agriculture.

Outreach

1. Conduct preliminary yield trials with beans and cowpeas in cooperation with the institutions concerned, at CIAT, Cali, Colombia; IICA, Turrialba, Costa Rica; EAP, El Zamorano, Honduras; DGIEA, El Salvador; and Col. P-G, Chapingo, Mexico.
2. Announce the release of newly developed lines of beans and cowpeas and distribute seed to interested breeders.
3. Prepare plans for a grain legume disease workshop to be held in cooperation with CIAT in late 1975.

Budget 1975-76

Line Item	
1. Salaries	$198,229
2. Fringe Benefits	33,699
3. Honoraria	1,000
4. Travel	9,908
5. Equipment & Supplies	22,600
6. Other Direct Costs	7,000
7. Indirect Costs (Overhead)	112,990
Total	$385,426

H. APPENDIXES

Appendix I

United States Department of Agriculture
Agricultural Research Service
Washington, D. C., 20250

Notice to Plant Breeders of the Release of Fourteen Selected Rust Resistant Bean Lines

The Agricultural Research Service, United States Department of Agriculture announces the release of fourteen selected bean (Phaseolus vulgaris L.) lines resistant to bean rust (Uromyces phaseoli (Pers.) Wint. var. typica Arth.). These lines are also high temperature tolerant and are adapted to humid tropical environment.

This project is supported in part by the Agency for International Development under a contract (PASA AJ-3-00) entitled "Regional Food Legume Improvement."

In early 1970 close to 1,000 bean PI accessions and hybrids were observed for rust response and 332 rust free lines were selected for screening during the short and hot dry period, mid-January to late July. Further field screening tests during 1971 to 1972 resulted in the selection of a few resistant lines which were increased in the spring of 1973. Inoculation tests at Beltsville, Maryland and in New South Wales, Australia have indicated that these selected lines contain resistance against a wide range of races. The rust resistant lines are divided into two groups according to their resistance to common bean mosaic virus.

Lines being released are:

a) The common bean mosaic resistant group:

1) Lines with semi-vine, black dull, and pea bean type seed: PR-S-70-15-R42-1-Bk, flowering at 36 days and an early selection from PI 268108; PR-S-70-15-R52-Bk, flowering at 36 days and a mid-season bulk selection from PI 306159; PR-S-70-15-R55-Bk, flowering at 37 days and a late maturing selection from PI 306162; PR-S-70-15-R57-Bk, flowering at 39 days and a late maturing selection from PI 151027; and PR-S-70-15-R66-1-Bk, flowering at 30 days

and early selection from PI 307751. 2) Lines with vine habit, flowering at 41 days, mid-season maturing, heavy yielding, and with brown dull and navy bean type seed: PR-S-70-15-R189-1-Bk, a selection from PI 207179; PR-S-70-15-R193-L-Bk, a selection from PI 306151; and PR-S-70-15-R194-2-Bk, an open pollinated hybrid with a shiny seed coat obtained from a dull seed coat selection of PI 306151.

b) The common bean mosaic susceptible group:

PR-S-70-15-R87-Bk, a semi-vine, flowering at 38 days, mid-season with black dull seed, selected from PI 311809; PR-S-70-15-R148-Bk, a vine, flowering at 36 days, late maturing with red shiny seed, selected from PI 209481; PR-S-70-15-R167-4-Bk, an open pollinated hybrid with vine habit, flowering at 35 days, early with tan shiny seed, selected from PI 208774; PR-S-70-15-R180-Bk, a semi-vine, flowering at 36 days, late maturing with pink shiny seed, selected from PI 310830; PR-S-70-15-R287-1-Bk, a semi-vine, flowering at 33 days, late maturing with pink shiny seed, selected from PI 208774; and PR-S-70-15-R292-Bk, a semi-vine, flowering at 39 days, late maturing with buff dull seed, selected from PI 309863. This is a varied group and the lateness of some selections could be due to susceptibility to the virus. Seeds of these lines resemble red Mexican beans in shape.

These lines are released as parental material in breeding for rust resistance or as differential bean varieties for rust resistance. The Department reserves the right to name any of these breeding lines if they are cultivated commercially.

A limited amount of seed is available by writing to Dr. N. G. Vakili, Federal Experiment Station, P. O. Box 70, Mayaguez, Puerto Rico 00708.

Approved:

Administrator
Agricultural Research Service

3/11/74
Date

United States Department of Agriculture
Agricultural Research Service
Washington, D.C. 20250

Notice to Plant Breeders of the Release of three Dry Bean Hybrids with Multiple Disease Resistance Characteristics

The Agricultural Research Service, United States Department of Agriculture announces the release of three dry bean (*Phaseolus vulgaris* L.) hybrid cultivars possessing a high degree of resistance, under tropical conditions, to a number of diseases.

This work is supported in part by the Agency for International Development under the project number (PASA AJ-3-00) entitled "Regional Food Legume Improvement."

The environment of the tropical lowlands is unfavorable to the cultivation of beans. Continuous warm weather, heavy seasonal rainfalls alternated by dry periods, rapid growth of weeds, a multitude of ever present insect pests and vectors, and the pressure of soil borne and foliage diseases drastically reduce the stand, vigor and the yield of beans. Cultivars with multiple resistance are needed, if cultivation of beans in the lowland tropics are to be an economic feasibility.

In Puerto Rico the development of hybrid beans with wide range of disease resistance was facilitated by a high frequence of open pollination in the field, caused by the visitation of the flowers by a Carpenter bee (*Xylocopa brasilianorum* L.) and by the possibility of growing four hybrid generations per year. Due to open pollination by the bees, only the maternal parents of these hybrids are known. The three hybrid cultivars were originally selected for cultivation in Latin American countries where black shiny beans are favored. They were also selected for tolerance to warm weather during flowering.

The hybrid cultivars being released are:

1. Cultivar designation: PR-H-71-1-R101.

Cultivar PR-H-71-1-R101 originated from a black dull seed and vine type, maternal parent from PI 200956 which was acquired from El Salvador. The black shiny F_2 progeny was screened for common bean

mosaic virus resistance. The F_3 and F_4 progenies were screened for common bean mosaic virus and rust resistance. The cultivar was bulked and increased at the F_5 generation. It has a vine habit, flowers at 47 days and has a small Navy bean-type black shiny seed.

2. Cultivar PR-H-71-1-R113.

The maternal parent of this cultivar is PI 289377 which has black dull seed, vine habit, and was acquired from Hungary. This cultivar was screened and selected as the previous one and increased at the F_5 generation. It has black shiny seed, semi-vine habit and flowers at 47 days.

3. Cultivar PR-H-71-1-R136.

The maternal parent of this hybrid is PI 195364 which has black dull seed, vine habit, and was acquired from Guatemala. The black shiny seeded hybrid was screened and selected as the previous ones and increased at F_5 generation. It has Navy bean-type seed, semi-vine habit and flowers at 47 days.

All three cultivars were resistant to:

Common bean mosaic virus. The three hybrid progenies were repeatedly subject to field and greenhouse screening in Puerto Rico and finally at Beltsville against strains BV-1, PR-5 and PR-9. These cultivars were free from infections in two seasonal field trials in El Salvador.

Seedlings of the three cultivars were resistant to Puerto Rico cowpea mosaic virus which is similar to the Arkansas cowpea mosaic virus. This virus is transmitted by chewing insects and is one the most prevalent diseases in the tropics. Also, seedlings of these cultivars were resistant to a strain of cucumber mosaic virus which affects a number of bean cultivars in the tropics.

Rust (Uromyces phaseoli var. typica). The three hybrid cultivars were screened for rust resistance at the F_3 to F_5 generations. During the past three years, these cultivars have been resistant to rust races which severely infect all North American rust differential bean varieties. At Beltsville PR-H-71-1-R113 had an immune response while the other two cultivars were resistant. At San Andres, El Salvador, these cultivars were moderately resistant while in New South Wales, Australia they had a resistant reaction to rust inoculation.

Fusarium wilt (Fusarium oxysporum f. sp. phaseoli). The three hybrid cultivars were put through a severe fusarium wilt screening at F_2 and F_3 generations in the field.

In El Salvador, cultivar PR-H-71-1-136 was infected with Rhizoctonia root rot (Rhizoctonia solani) and cultivar PR-H-71-1-R113 was attacked by web blight (Thanatephorus cucumeris).

No powdery mildew (Erysiphe polygoni) infection have been recorded on these cultivars either in Puerto Rico or in El Salvador.

Golden Yellow Mosaic. The white fly transmitted virus disease, golden yellow mosaic, is one of the most important diseases of beans in the lowland tropics. Cultivar PR-H-71-1-R101 has been susceptible to this virus both in Puerto Rico and in El Salvador. The other two cultivars have shown field tolerance.

The three cultivars are susceptible to Xanthomonas phaseoli and X. vignicola the causal organisms of common bacterial blight of beans and bacterial canker of cowpeas, respectively.

The three cultivars, though having black shiny beans and vine to semi-vine habit, possess a wide range of resistance and could be cultivated commercially where black beans are the preferred local staple Also, these cultivars could be used as resistant parents for crosses with adaptable and commercially desired local varieties.

A limited amount of seed is available by writing to Dr. N.G. Vakili, Federal Experiment Station, P.O. Box 70, Mayaguez, Puerto Rico 00708.

Administrator
Agricultural Research Service

1/4/74
Date

Appendix II

A. Bibliographic List of Papers and Publications Developed Under the Contract.

1. Bird, J. and J. H. López-Rosa. 1973. New whitefly and aphid-borne viruses of bean (Phaseolus vulgaris) in Puerto Rico. Proceedings of the First IITA Grain Legume Improvement Workshop, Ibadan, Nigeria, 29 Oct. - 2 Nov., 276-278.

2. Bird, J., J. Sánchez, R. L. Rodríguez, A. Cortés-Monllor, and W. Kaiser. 1974. A mosaic of beans (Phaseolus vulgaris L.) caused by a strain of common cucumber mosaic virus. J. Agr. Univ. P.R. 58(2): 151-161.

3. Bird, J., J. Sánchez, R. L. Rodríguez, and F. J. Juliá. Rugaceous (whitefly-transmitted) viruses in Puerto Rico. In Tropical Diseases of Legumes, Julio Bird & Karl Maramorosch, Ed., Academic Press (volume to appear in 1975).

4. Bird, J., J. Sánchez, R. L. Rodríguez, A. Cortés-Monllor, W. Kaiser, H. W. Waterworth, and R. H. Lawson. A vein banding mosaic of beans incited by a strain of cucumber mosaic virus. In Tropical Diseases of Legumes, Julio Bird & Karl Maramorosch, Ed., Academic Press (volume to appear in 1975).

5. Bird, J., J. Sánchez, and R. L. Rodríguez. 1974. Virus affecting soybeans in Puerto Rico. Proceedings of the Workshop on Soybeans for Tropical and Subtropical Conditions held at the University of Puerto Rico, Mayaguez Campus - Intsoy Publication Series, No. 2, 109-111, May 1974.

6. Hirumi, H., M. Kimura, K. Maramorosch, J. Bird, and R. Woodbury. 1974. Rickettsia-like organisms in the phloem of little leaf diseased Sida cordifolia. Phytopathology 64: 581-582.

7. Maramorosch, K., H. Hirumi, M. Kimura, J. Bird, and N. G. Vakili. 1974. Diseases of pigeon pea in the Caribbean area: an electron microscopy study. FAO Plant Protection Bull. 22(2): 32-36.

8. Milbrath, G. M., J. Bird, and J. Sánchez. Isolation of a strain of cucumber mosaic virus from beans in Illinois. In Tropical Diseases of Legumes, Julio Bird & Karl Maramorosch, Ed., Academic Press (volume to appear in 1975).

9. Rodríguez, R. L., J. Bird, A. Cortés-Monllor, H. E. Waterworth, M. Kimura, and K. Maramorosch. A mosaic disease of Canavalia maritima (bay-bean) in Puerto Rico. In Tropical Diseases of Legumes, Julio Bird & Karl Maramorosch, Ed., Academic Press (volume to appear in 1975).

10. Vakili, N. G. and K. Maramorosch. 1974. Witch's broom disease caused by mycoplasm-like organisms on pigeon peas (Cajanus cajan) in Puerto Rico. Plant Disease Reporter 58: 96.

11. Vakili, N. G. 1974. Bacterial blight of beans (Phaseolus vulgaris) caused by Xanthomonas phaseoli and X. vignicola in lowland tropics. Workshop on Grain Legume Diseases, Agricultural Experiment Station, University of Puerto Rico, Río Piedras, P.R.

12. Vakili, N. G. 1974. Distribution of wild hosts of whitefly transmitted viruses in Tropical America. Workshop on Grain Legume Diseases, Agricultural Experiment Station, University of Puerto Rico, Río Piedras, P.R.

13. Vakili, N. G. 1974. Diseases of beans (Phaseolus vulgaris) in Tropical America. Workshop on Grain Legume Diseases, Agricultural Experiment Station, University of Puerto Rico, Río Piedras, P.R.

14. Vakili, N. G. 1974. Survey of cowpea (Vigna unguiculata) diseases in Tropical America. Carib. Div. APS, Port of Spain, Trinidad.

B. Abstracts of Papers and Publications Developed Under the Contract.

NEW WHITEFLY AND APHID-BORNE VIRUSES OF BEAN (*PHASEOLUS VULGARIS*) IN PUERTO RICO. Julio Bird and Julio H. López-Rosa

Several rugaceous viruses are known to occur in Puerto Rico. Four of them, i.e., *Rhynchosia*, *Jacquemontia*, *Ipomoea* and *P. lunatus* mosaic viruses are whitefly-transmitted and affect beans (*P. vulgaris*) in the field. The Rhynchosia and *P. lunatus* viruses are well distributed in the Island and also seem to be present in other Caribbean islands as well as in Central America and Northern South America. The results of host range and cross protection studies indicate that the Puerto Rican whitefly-transmitted viruses are not closely related. The *Ipomoea*, *Jacquemontia* and *P. lunatus* viruses have a rather restricted host range; the former causes a yellow leaf curl of tomato. The *Rhynchosia* virus affects many species belonging to several plant families. Certain bean varieties have shown some degree of tolerance to the *Rhynchosia* virus. No resistance to the *P. lunatus* virus has been encountered in the many bean varieties tested. A seemingly new strain of cucumber mosaic virus (CMV) transmitted by *Aphis gossypii* was found to be affecting beans in Puerto Rico. Little is known about the distribution of this agent in the Island. The aforementioned strain of CMV seems to be related to the one that occurs on *Commelina* in Puerto Rico. In addition, it causes symptoms on banana that are indistinguishable from those incited by the local banana mosaic virus which has been shown to be a strain of CMV. The *P. lunatus* virus was transmitted mechanically in Puerto Rico by a French visiting scientist, Dr. Hervé Lot.

Proceedings of the First IITA Grain Legume Improvement Workshop, Ibadan, Nigeria, 29 Oct.-2 Nov., 276-278 (1973)

A MOSAIC OF BEANS (PHASEOLUS VULGARIS L.) CAUSED BY A STRAIN OF COMMON CUCUMBER MOSAIC VIRUS. J. Bird, J. Sánchez, R. L. Rodríguez, A. Cortés-Monllor, and W. Kaiser

A virus (BVBMV) capable of inciting mild mosaic and vein-banding symptoms on various hosts was isolated from field beans (*Phaseolus vulgaris* L.) growing in experimental plots. The causal agent was transmitted by mechanical means as well as via aphids. The results of transmissibility, serology, host range and physical property studies indicate that the virus is a strain, possibly a new one, of the common cucumber mosaic virus (CMV) complex.

Un virus (BVBMV) capaz de provocar ligeros síntomas de mosaico y el bandeado de las nervaduras en varias especies de plantas fue aislado de habichuelas (*Phaseolus vulgaris* L.) cultivadas en un predio experimental. El virus se transmitió por medios mecánicos y a través de varias especies de áfidos. Los resultados obtenidos de estudios realizados sobre la transmisibilidad, gama de plantas hospedadoras, serología y propiedades físicas del referido agente viroso indican que se trata de una cepa, posiblemente nueva, del mosaico común del pepinillo (CMV).

J. Agr. Univ. P.R. 58(2): 151-161 (1974)

VIRUSES AFFECTING SOYBEANS IN PUERTO RICO. J. Bird, J. Sánchez and R. L. Rodríguez

La soja no se siembra comercialmente en Puerto Rico a pesar de que se pueden obtener magníficos rendimientos mediante el empleo de prácticas tecnológicas modernas. Hasta ahora poco se conocía sobre los virus fitopatogénicos que afectan la antedicha cosecha en Puerto Rico. Recientemente se observaron dos mosaicos en plantaciones experimentales localizadas en las Subestaciones de Fortuna, Lajas, Gurabo e Isabela. La incidencia de uno de los mosaicos, el enanismo (achaparramiento) amarillo, era elevada (más de 25% en algunas variedades) en la Subestación de Fortuna pero casi inapreciable (aproximadamente 1%) en Isabela, Gurabo y Lajas. El virus que causa el enanismo amarillo no pudo ser transmitido por medios mecánicos pero se verificó experimentalmente que era propagado por la mosca blanca Bemisia tabaci Genn. Los resultados de estudios sobre la transmisibilidad, sintomatología y gama de hospederas indican que el agente que causa el enanismo amarillo de la soja en Puerto Rico es idéntico al incitado por el virus rugáceo de Rhynchosia minima DC. El otro virus detectado en el campo causa un mosaico efímero en la soja y fue transmitido experimentalmente (por medios mecánicos) a plantas de la variedad Jupiter. Otras especies corrientes tales como pepinillo, tabaco, habichuela y caupi no desarrollaron síntomas al ser inoculadas artificialmente. Los agentes que causan los mosaicos de Crotalaria y Vigna son capaces, según comprobamos, de infectar la soja en Puerto Rico. Sin embargo no logramos aislar estos agentes de las plantaciones antes mencionadas.

Proceedings of the Workshop on Soybeans for Tropical and Subtropical Conditions - Intsoy Publication Series, No. 2, 109-111 (1974)

RICKETTSIALIKE ORGANISMS IN THE PHLOEM OF LITTLE LEAF-DISEASED SIDA CORDIFOLIA. H. Hirumi, M. Kimura, K. Maramorosch, J. Bird, and R. Woodbury .

Sida cordifolia plants with a previously undescribed little leaf disease were observed growing wild at Lagos de Vega Baja, Puerto Rico. The diseased plants were characterized by dwarfed leaves, reduction in internode length, and suppression of flowering. Occasionally leaves on several branches were severely dwarfed, while leaves on other branches of the same plant appeared normal. To elucidate the etiology of the disease, portions of leaves and petioles were excised in the field, fixed with 1.5% glutaraldehyde in 0.1 M sodium cacodylate buffer (pH 7.2), and further processed for electron microscopy using standard procedures. Examination of thin-sections revealed the presence of pleomorphic microorganisms, resembling Rickettsiae (RLO), in the sieve tube elements, but not in the xylem, of diseased as well as healthy-appearing S. cordifolia collected in the same area. The RLO were either spherical or filamentous and had thin cell walls that distinguished them from mycoplasmalike organisms (MLO). Healthy S. cordifolia from a location 2 kilometers away contained no microorganisms. Presumably RLO represent a group of plant pathogens, distinct from MLO and from bacteria.

Phytopathology 64: 581-582 (1974)

DISEASES OF PIGEON PEA IN THE CARIBBEAN AREA: AN ELECTRON MICROSCOPY STUDY. K. Maramorosch, H. Hirumi, M. Kimura, J. Bird, and N. G. Vakili

At least four different diseases of uncertain etiology affect pigeon pea, Cajanus cajan, plants in the Caribbean Islands. The whitefly-borne agent of the yellow mosaic disease has not been visualized by electron microscopy and may be a viroid, rather than a virus. The proliferation or witches' broom disease observed in the Dominican Republic, as well as the more severe proliferation disease occurring in Puerto Rico, has been found associated with mycoplasma-like micro-organisms, as well as a rhabdo-type virus. Plants infested by Empoasca leafhoppers showed mild proliferation symptoms and typical hopper burn. No viruses or mycoplasma-like disease agents were found in such plants. Healthy plants were free from viruses and MLO.

FAO Plant Protection Bull. 22(2): 32-36 (1974)

Appendix III

Travel by the Staff

A. National

1. Dr. Vakili visited (August 19-20) the Regional Plant Introduction Station, USDA, ARS, Washington State University, Pullman, Washington to discuss exchange of information and materials. He was invited to give a seminar on Tropical Diseases of Beans.

2. Dr. Vakili visited (August 21-22) the Food Legume Improvement Project facilities, USDA, ARS, Pasco, Washington and arranged for exchange of breeding lines for inclusion in disease resistance trials.

3. Drs. Freytag and Vakili participated (September 16-17) in the WRCC-10 Technical Committee Meeting, USDA, ARS, held at the University of Colorado, Fort Collins, Colorado.

4. Dr. Cruz attended (December 1-6) the Annual Meeting of the Entomological Society of America held at Minneapolis, Minnesota.

B. International

1. Honduras

Dr. López-Rosa participated (February 11-15) in the 20th Annual Meeting of the Programa Cooperativo Centroamericano Para el Mejoramiento de Cultivos Alimenticios (PCCMCA) held in San Pedro Sula, Honduras, C.A.

2. Canada

Drs. Vakili and López-Rosa attended (August 11-16) the joint Annual Meeting of the American Phytopathological Society and the Canadian Phytopathological Society held in Vancouver, British Columbia, Canada.

3. Colombia

Drs. Vakili, Meléndez and López-Rosa participated (October 10-12) in the Bean Rust Workshop held at the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. Dr. López-Rosa participated (October 14-16) in the Bean Program Evaluation Workshop held at CIAT.

4. Ecuador

Dr. Vakili visited (October 14-19) the Instituto Nacional de Investigación Agrícola at Quito; the Estación Experimental Santa Catalina (INIAP), at Santa Catalina; the Estación Experimental de Pichilingue; and the Estación Experimental Boliche, at Guayaquil. The objective of these visits was to discuss and arrange for cooperative research on diseases resistance in Phaseolus vulgaris and Vigna unguiculata.

5. Perú

Dr. Vakili visited (October 20-24) the Centro Nacional de Investigación, at La Molina to discuss possible cooperative work on disease resistance in beans.

6. Trinidad

Dr. Vakili attended (November 17-23) the Annual Meeting of the Caribbean Division of the American Phytopathological Society held at Port of Spain, Trinidad. He presented the paper "Survey of Cowpea Diseases (Vigna unguiculata) in Tropical America".

7. Guyana

Dr. Vakili visited Guyana (November 25-27) at the request of the AID mission in that country. The objective of the visit was to discuss possible use of legumes such as cowpeas and pigeon peas as forage crops.

8. Venezuela

Dr. Vakili visited (November 28-December 5) the Instituto de Investigaciones Agronómicas at Maracay; the Universidad Centro Occidental at Barquisimeto; and the Centro de Investigaciones Agropecuarias de la Región Centro Occidental at Acarigua. The objective of these visits was to arrange cooperative research on disease resistance in beans and cowpeas. At the Department of Plant Pathology, Universidad Centro Occidental he lectured on "Disease Resistance in Beans and Cowpeas".

Appendix IV

Visitors Interested in Grain Legume Disease Research

Name	Address
1. Dr. Richard Ford	Plant Pathology Department University of Illinois Urbana, Illinois 61801
2. Dr. George L. Godfrey	idem
3. Dr. Gene L. Milbrath	idem
4. Dr. James B. Sinclair	idem
5. Dr. Robert Goodman	idem
6. Dr. J. M. Poehlman	Agronomy Department University of Missouri-Columbia 208 Waters Columbia, Missouri 65201
7. Dr. Vernon Dansteegt	U.S. Department of Agriculture Frederick, Maryland
8. Dr. J. P. Meiners	Plant Protection Institute Agricultural Research Service U.S. Department of Agriculture Beltsville, Maryland 20705
9. Dr. H. E. Waterworth	Plant Introduction Station Agricultural Research Service U.S. Department of Agriculture P.O. Box 88 Glenn Dale, Maryland 20769
10. Dr. Russell Desrosiers	Agency of International Development Department of State Washington, D.C. 20523
11. Mr. Heleodoro Miranda	Instituto Interamericano de Ciencias Agrícolas Apartado 1688, Sucursal #1 San Salvador, El Salvador
12. Dr. Eddie Echandi	Department of Plant Pathology North Carolina State University Raleigh, North Carolina 27607

13.	Dr. Alvaro S. Costa	Virology Department Instituto Agronomico Campinas, S.P., Brazil
14.	Dr. Guillermo Gálvez	Centro Internacional de Agricultura Tropical Apartado Aéreo 67-13 Cali, Colombia
15.	Mr. Carlos Granillo	Facultad de Ciencias Agronómicas Universidad de El Salvador San Salvador, El Salvador
16.	Mr. Antonio Díaz Chávez	División de Parasitología Vegetal Centro Nacional de Tecnología Agropecuaria Santa Tecla, El Salvador
17.	Dr. Gordon Muller	Ministry of Agriculture Guyana
18.	Dr. Reginald E. Pierre	Faculty of Agriculture University of the West Indies Mona, Kingston 7, Jamaica
19.	Dr. John A. Spence	Dept. of Biological Sciences University of the West Indies St. Augustine, Trinidad, W.I.
20.	Dr. N. D. Singh	Department of Crop Sciences University of the West Indies St. Augustine, Trinidad, W.I.
21.	Dr. S. Q. Haque	idem
22.	Dr. Karl Maramorosch	Waksman Institute of Microbiology Rutgers University New Brunswick, New Jersey 08903
23.	Dr. James E. Duffus	U.S. Agricultural Station P.O. Box 5098 Alisal Branch Salinas, California 93901
24.	Dr. Floyd F. Smith	Plant Genetics & Germ Plasm Institute USDA, ARS, Building 470 Agricultural Research Center-East Beltsville, Maryland 20705

25.	Dr. Robert J. Williams	International Institute of Tropical Agriculture (IITA) Oyo Road, PMB 5320 Ibadan, Nigeria
26.	Dr. Francis Koo	Tropical Agro-Sciences Division Puerto Rico Nuclear Center University of Puerto Rico Mayaguez, Puerto Rico 00708
27.	José M. Arrieta	Graduate Student Mayaguez Campus University of Puerto Rico Mayaguez, Puerto Rico 00708
28.	Domingo Bee-Rodríguez	idem
29.	Donald Bravo-Flores	idem
30.	Rodrigo J. Echávez-Badel	idem
31.	Sonia Esteves-Velázquez	idem
32.	José A. González-Rodríguez	idem
33.	Ernesto Leypón-Noguera	idem
34.	Miguel A. López-Guadamuz	idem
35.	Pastor Petit-Rondón	idem
36.	Frank Sequeira-Bustamante	idem
37.	Ivonne Villamarzo	idem

Appendix V

Recipients of Seeds from Released Bean Lines

United States

John L. Bowers, Professor of Horticulture, Department of Horticulture and Forestry, University of Arkansas, Fayetteville, Arkansas 72701

10 cowpea lines

George Bruening, Assoc. Professor, Department of Biochemistry and Biophysics, University of California, Davis, California

12 bean lines

Mark J. Bassett, Asst. Professor, University of Florida, IFAS, Gainesville, Florida

14 bean lines

L. Curtis Hannah, Asst. Professor, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida 32611

11 cowpea lines

Mark J. Bassett, Asst. Professor, University of Florida, IFAS, Gainesville, Florida 32611

3 bean lines

Richard W. Hartmann, Assoc. Professor of Horticulture, College of Tropical Agriculture, St. John Plant Science Laboratory 102, 3190 Maile Way, University of Hawaii, Honolulu, Hawaii 96822

3 bean lines
14 rust resistant bean lines

J. P. Meiners, Chief, Applied Plant Pathology Laboratory, Agric. Res. Center, Beltsville, Maryland 20705

11 bean lines

R. Provvidenti, Senior Research Associate, New York State Agricultural Experiment Station, Cornell University, Geneva, New York

3 bean lines

R. E. Wilkinson, Department of Plant Pathology, Cornell University Ithaca, New York 14850

370 bean lines

D. H. Wallace, Professor, Department of Plant Breeding and Biometry, Cornell University, 252 Emerson Hall, Ithaca, New York 14850

1 bean line

Edward K. Vaughan, Professor of Plant Pathology, Department of Botar and Plant Pathology, Oregon State University, Corvallis, Oregon 973:

9 cowpea lines

W. L. Ogle, College of Agricultural Sciences, Clemson University, Clemson, South Carolina 29631

4 cowpea lines
1 bean line

Richard L. Fery, Res. Geneticist, U.S. Vegetable Laboratory, Box 3348, Charleston, South Carolina 29407

cowpea and bean lines

M. J. Silbernagel, Res. Plant Pathologist, Irrigated Agriculture Research and Extension Center, Prosser, Washington 99350

3 bean lines

L. W. Hudson, Asst. Horticulturist, Regional Plant Introduction Station, Washington State University, Pullman, Washington 99163

18 bean lines

Puerto Rico

Carlos Cruz, Isabela Substation, Isabela, Puerto Rico

52 cowpea lines
45 bean lines

José Vicente Chandler, Río Piedras Agricultural Experiment Station, Río Piedras, Puerto Rico

1 bean line

J. Vélez Fortuño, Plant Breeder, Agricultural Experiment Station, Río Piedras, Puerto Rico

4 bean lines
11 cowpea lines

Jessé Román, Agricultural Experiment Station, Río Piedras, Puerto Ric

22 bean lines
26 cowpea lines

Marcial Rico Ballester, Agricultural Experiment Station, Lajas, Puerto Rico

17 cowpea lines
11 bean lines

Dr. Koo, Nuclear Center, Mayaguez, Puerto Rico

6 bean lines

Foreign Countries

Australia

Miss Barbara Ballantyne, Department of Agricultural Botany, The University of Sydney, Sydney 2006, New South Wales, Australia

2 bean lines

Austria

S. C. Hsieh, Division of Research and Laboratories, Plant Breeding and Genetics Section, International Atomic Energy Agency, Karntner Ring 11, P. O. Box 590, A-1011, Vienna, Austria

4 bean lines
8 cowpea lines

Basseterre

S. George Pencle, Chief Agricultural Officer, Department of Agriculture, St. Kitts, Nevis, Anguilla, Basseterre

3 cowpea lines

Brazil

Engo. Agro. Eduardo Humberto O. Barbosa, Jefe de Sector Frijol, Instituto de Pesquisas Agropecuarias do Lestre, 44.30 - Crur das Almas, Bahia, Brazil

1 bean line
1 cowpea line

Dr. A. S. Costa, Head, Virus Department, Instituto Agronomico, 13.100 Campinas, Sao Paulo, Brazil

2 bean lines

E. H. Paschal II, Purdue Contract, Am Cons/Rio/Vicosa, APO New York 09676

11 bean lines

John M. Yohe, Plant Breeder, EMBRAPA Project, AMCONGEN-RECIFE, APO N.Y., N.Y. 09676

3 cowpea lines

John M. Yohe, Plant Breeder, AMCONGEN-RECIFE, APO New York 09676

10 cowpea lines

Republic of China

Leonard Ho, Asst. Breeder, The Asian Vegetable Research and Development Center, Shanhua, Tainan, 741, Taiwan, Republic of China

14 bean lines

Colombia

Charles A. Francis, Coordinator, Small Farm Systems Program, CIAT, Cali, Colombia

3 cowpea lines

Costa Rica

Antonio M. Pinchinat, Geneticist, Centro Agronómico Tropical de Investigación y Enseñanza, Turrialba, Costa Rica

1 bean line
1 cowpea line

Ecuador

Ing. Hector Buestán, Jefe Encargado del Programa de Leguminosas de la E. E. Boliche, Guayaquil, Ecuador

3 cowpea lines

El Salvador

Ing. Agron. Antonio Díaz Chávez, Centro Nacional de Agronomía, Ministerio de Agricultura, Santa Tecla, El Salvador

2 bean lines

Ethiopia

Staley L. Pitts, Pulse Project Officer, AID, United States AID Mission to Ethipia, Addis Adaba, Ethiopia

17 bean lines

Guadeloupe

R. Bonhomme, Domaine Duclos, 97170 - Petit-Bourg, Guadeloupe

1 cowpea line

Guatemala

Dr. Ricardo Bressani, Head, Division of Agricultural and Food Sciences, Instiuto de Nutrición de Centro América y Panamá, Guatemala, C.A.

3 cowpea lines

Haiti

Roland Latortue, Service des Recherches Agricolas, Department de l'Agriculture, Damien, Port-au-Prince, Haiti

14 bean lines

Honduras

Napoleon Reyes Discua, Investigación Agropecuaria, Desarrollo Agropecuario, Secretaría de Recursos Naturales, Tegucigalpa, D.C., Honduras

20 cowpea lines
6 bean lines

Kenya

Dr. Walter J. Kaiser, Head, Division of Plant Quarantine Service, East African Community, Nairobi, Kenya

3 cowpea lines
2 bean lines

Malawi

L. L. Smuti-Phiri, Coordinator - Minor Legume Projects, Agricultural Research Council of Malawi, Grain Legume Research Laboratory, Box 215, Lilongwe, Malawi

596 cowpea lines

M. A. Siddigi, Principal Plant Pathologist, Plant Pathology Service, Bvunbwa, Box 5748, Limle, Malawi

9 disease resistant selections

Nicaragua

José Angel Ponce B., Encargado, Sección Leguminosas de Grano, CEIEA, Managua, Nicaragua

10 cowpea lines
4 bean lines

Fermin Balerdi, Consultor, Proyecto Adelante, Leon, Nicaragua

cowpea lines

Nigeria

U. U. Ebong, Federal Dept. of Agric. Research, Moor Plantation, P.M.B. 5042, Ibadan, Nigeria

Perú

Oswaldo Voy. est V., Head, Grain Legumes Department, Centro Regional de Investigación Agraria - La Molina, Lima, Perú

14 bean lines

Philippines

Noel G. Mamicpic, Asst. Professor and Chairman, Department of Agronomy, University of the Philippines, College, Laguna, Philippines

3 cowpea lines

St. Lucia

Calixte George, Research Officer, Ministry of T.I.A.T., Castries St. Lucia

4 cowpea lines

Thailand

Wallace E. Manis, Agricultural Research Officer, U.S. Consulate, APO San Francisco 96272

17 bean lines

Trinidad

H. G. Schuetz, Project Director, Chaguaramas Agricultural Development Project, Macqueripe/Chaguaramas, Trinidad and Tobago

19 bean lines
13 cowpea lines

Venezuela

Luis Marcano C., Fundación Servicio para el Agricultor, Caracas, Venezuela

4 bean lines
9 cowpea lines

Appendix VI

Statements that Identify Use of Materials and Information Produced by the Project

1. The methodologies developed in Puerto Rico for the establishment and maintenance of stock cultures of Bemisia tabaci and mechanical inoculation of bean plants with rugaceous (whitefly transmitted) viruses will enable scientists to adequately study similar diseases in other parts of the world.

2. The workshop on grain legume diseases, which gathered workers from Africa, South and Central America, the Caribbean and the United States, offered an opportunity for participants to exchange information and ideas, and to plan cooperative research. The establishment at CIAT, Cali, Colombia, of a central bank of diagnostic plant species (part of the seed contributed by the Project) for use in studies of rugaceous maladies throughout the tropical world is a direct result of the workshop. A lasting contribution from this seminar will be the publication of the proceedings in a volume which will be available shortly from Academic Press.

3. Seeds of advanced lines and hybrids released in 1974 (Appendix I - Section H) were requested by cooperators and interested researchers in 25 foreign countries, nine states of the United States, and others in Puerto Rico (Appendix V - Section H). In the foreign countries, 29 researchers received 19 sets of Phaseolus vulgaris and 20 sets of Vigna unguiculata multiple disease resistant lines. In the United States,

13 researchers received 13 sets of P. vulgaris and five of V. unguiculata multiple disease resistant lines. In Puerto Rico, six researchers received five P. vulgaris and four V. unguiculata multiple resistant lines. In Puerto Rico, six researchers received five P. vulgaris and four V. unguiculata multiple resistant lines. Recipients of seeds are evaluating the materials for resistance to diseases and as parental stock for breeding programs (pp. 10-11).