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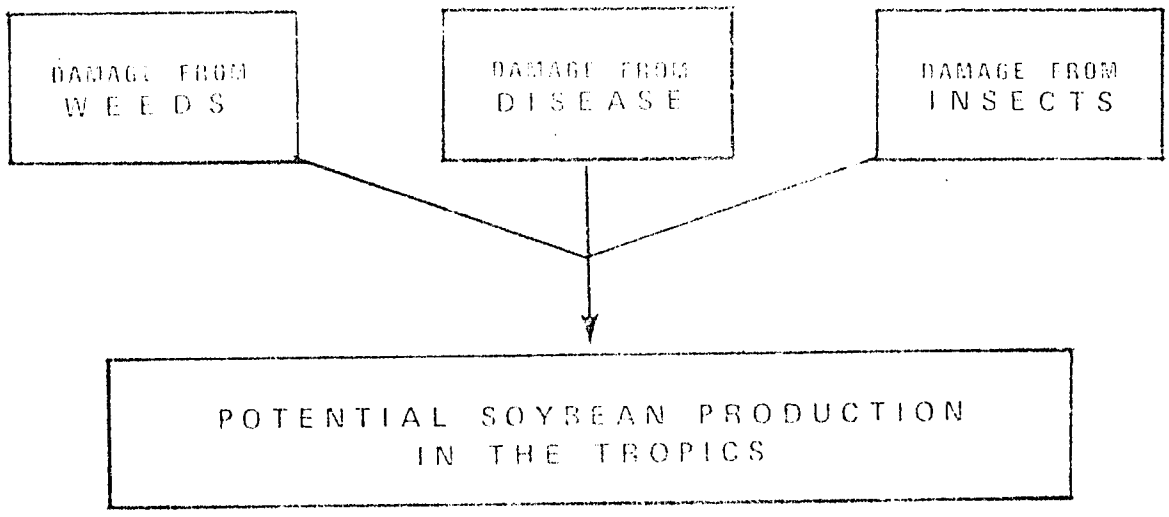
A GRANT TO STRENGTHEN THE INSTITUTIONAL RESPONSE CAPABILITIES OF THE UNIVERSITY OF PUERTO RICO IN CROP PROTECTION OF SOYBEANS FOR TROPICAL AND SUBTROPICAL AREAS



ANNUAL REPORT OF GRANT AID/CM/TA-G-73-50
OCTOBER 1, 1977 TO SEPTEMBER 30, 1978

SUBMITTED TO

THE AGENCY FOR INTERNATIONAL DEVELOPMENT
DEPARTMENT OF STATE
WASHINGTON, D.C.

BY

DEPARTMENT OF CROP PROTECTION
COLLEGE OF AGRICULTURAL SCIENCE
UNIVERSITY OF PUERTO RICO
MAYAGUEZ CAMPUS
INTERNATIONAL SOYBEAN PROGRAM, INTSOY

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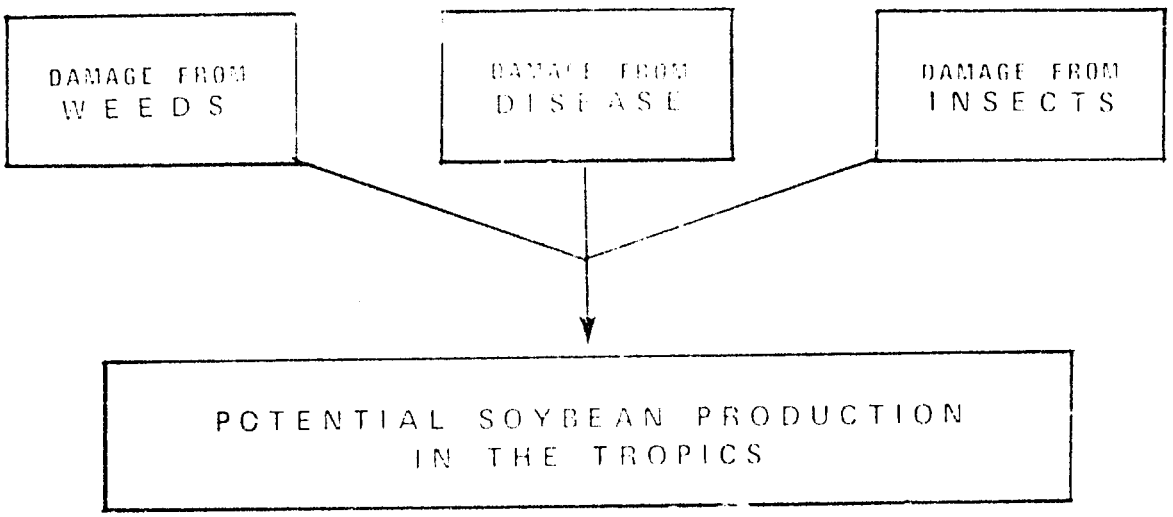

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Date Due: December 1, 1978

Date Submitted: January 1, 1979

A. Title Page

Grant Title: A Grant to Strengthen the Competence of the University of Puerto Rico in Disease Control and Related Insects and Cultural Practices of Soybeans and Other Food Legumes for Tropical and Subtropical Areas

Grantee: University of Puerto Rico, Mayaguez Campus

Grant Program Staff: Dr. Raul Abrams, Associate Director of INTSOY
Dr. Mike Ellis, Grant Director and Pathologist
Dr. Guillermo Riveros, Weed Scientist
Dr. Pedro Melendez, Pathologist
Dr. Nelia Acosta, Nematologist
Eileen Rosario, Research Assistant
Eduardo Riera, Laboratory Assistant
Rafael Ruiz, Laboratory Assistant
Rogelio Nieves, Field Assistant
Maria Pagan, Secretary

AID Sponsoring Technical Office: TA/AGR

Statistical Summary:

Period of Grant:	September 16, 1973 to September 16, 1980
Amount of Grant:	$837,676
Expenditures:	
a) Report Period	$121,851.47
b) Accumulated	$500,000
c) Anticipated for Next Year	$167,638.50

B. Narrative Summary

The University of Puerto Rico was granted $500,000 (AID/CM/ta-g-73-50) to cover the period of September 16, 1973 to September 16, 1978. The purpose of this grant is to strengthen the existing competence and institutional response capability of the University of Puerto Rico to provide training, research and informational linkages, technical assistance and consultation on major problems related to limiting diseases and associated insects and cultural practices of soybeans and other food legumes for the tropical and subtropical areas. The developed competencies are being used to increase significantly tropical soybean production, with the intent of improving the human diet of the low income areas of the world.

This grant is a collaborative effort with the University of Illinois. The Universities of Illinois and Puerto Rico complement each other with respect to developing an overall capability for conducting research and educational work on soybeans into the tropics.

At the beginning of the present grant, soybeans were of no economic importance (as far as production is concerned) to the Commonwealth of Puerto Rico; therefore, Puerto Rico's research and advisory capability in soybeans was very low. Through activities conducted under the present grant, Puerto Rico has made significant progress towards the development of a coordinated, interdisciplinary research and advisory program in the area of tropical crop protection of soybean.

At present, the University of Puerto Rico's soybean program (INTSOY-UPR) involves active research in the areas of plant pathology, weed science, and seed quality problems of soybean in the tropics. With emphasis on the development of an integrated, coordinated crop protection research and advisory team. INTSOY (University of Illinois) has established a position for a soybean breeder who is permanently stationed at Puerto Rico. Through cooperation and consultation with the UIUC breeder, the scope of our program is expanded to incorporate genetic variation of tropically adapted soybeans into the overall pest management and control program.

In July 1977, Dr. Stewart Smith (INTSOY-University of Illinois-Soil Microbiologist) joined the soybean program at UPR and will be of great value in determining and controlling problems related to nitrogen fixation and nodulation of soybean under tropical conditions.

In March 1978, Mr. James Oard (Assistant Agronomist-UIUC) joined the soybean program at UPR. Mr. Oard will assist the UIUC plant breeder in order to assure continued development of the INTSOY breeding program at Puerto Rico.

The development and strengthening of the University of Puerto Rico's existing competence and institutional response capability in the area of tropical production and protection of soybean has been demonstrated. Together, the University of Puerto Rico and the University of Illinois constitute the International Soybean Program (INTSOY), which they established in July 1973.

The grant has had a marked effect on the development of the University of Puerto Rico's plant sciences program. In July 1977, the College of Agricultural Sciences established the Department of Crop Protection. This new department is an attempt to integrate the disciplines of plant pathology, nematology, entomology, weed sciences and pesticide usage into a single program. The new department should facilitate the integration of teaching, research and extension in the science of crop protection. The department of crop protection has a staff of 50 scientists at the M.S. or Ph.D. level.

Grant staff members have been active in the development of a new curriculum for both the graduate and undergraduate programs within the new department. The new curriculum is intended to meet the needs of the department in providing integrated training in all areas of crop protection. At present, courses within the field of crop protection are being offered and graduate students are enrolled in the program. Grant personnel are involved in teaching graduate and undergraduate courses in the areas of plant pathology, weed science and nematology. Grant personnel are also active in advising graduate student thesis research at the M.S. level.

The University of Puerto Rico recognizes it's role in international outreach and training activities. Efforts are being made to increase these types of activities, in order to more fully utilize the results of research and existing staff competence of the program. Within this reporting period, the participation of program staff in international training activities has significantly increased. Program staff have participated in training and outreach activities in Costa Rica, Brazil, Peru, Colombia, Panama and Puerto Rico.

During the reporting period, UPR has accepted four graduate students from Peru. These students will be concentrating their M.S. thesis research in the areas of agronomy, soil microbiology and weed science. In addition one nondegree trainee from Peru was at UPR for five months engaged in work-study training in the area of seed pathology. It is anticipated that the experience gained by the previously mentioned Peruvian students will be extremely valuable in developing a strong national program for soybean production in Peru. In addition, Mr. Oswaldo Zambrano from Ecuador and Mr. Emilio Salaues from Bolivia both received their M.S. degrees in plant pathology and agronomy, respectively, and have returned to their countries to resume their research positions in soybean production.

The original grant terminated on September 16, 1978. AID has granted UPR a two year grant extension to cover the period from September 17, 1978 to September 16, 1980. Through this grant extension, the components of nematology and entomology are being incorporated into the overall grant program. In January 1978, Dr. Nelia Acosta joined the INTSOY-UPR staff. Dr. Acosta recently finished her Ph.D in nematology at the University of Illinois. Through research and training activities conducted by Dr. Acosta, the nematology component is incorporated into the overall tropical crop protection program for soybeans.

At present, UPR is interviewing candidates for an INTSOY-UPR entomologist. When the entomologist comes on board, the INTSOY-UPR research and advisory team will include the following disciplines: pathology, seed pathology, nematology, entomology and weed science.

Formal linkages with national and international organizations have been initiated within this reporting period.

C. Detailed Report

1. General Background and Description of the Problem

Malnutrition, caused by deficiencies in calories, protein and other nutrients affects an estimated 400 million to 1.5 billion of the world's poor. Hardest hit are children, whose growing bodies demand 2 1/2 times more protein, pound per pound, than those of adults. Nutrition experts estimate that 70 percent of the children in the low-income countries are affected. It is extremely difficult for a human being to work, think or smile when he or she is hungry and in a state of poor nutrition. Now and in the future a great deal of emphasis needs to be placed on the world food situation. Not only for humanitarian purposes, but to insure future world peace and stability.

Due to the lack of technology appropriate for their specific environmental, cultural and economic conditions, the world food picture does not present a pleasant outlook for many regions, especially in overpopulated areas of the tropics. However, through coordinated, international efforts in research and development, we can accomplish a great deal towards alleviating the program.

Food legumes such as soybean (*Glycine max*), field bean (*Phaseolus vulgaris*), cowpeas (*Vigna sinensis*), pigeon pea (*Cajanus cajan*), and others will become increasingly important in the tropical and subtropical regions of the world. All of these legumes provide an excellent source of inexpensive yet high quality vegetable protein. The potential production of many food legumes in the tropical and subtropical parts of the world has been clearly demonstrated. Recent research conducted by the University of Puerto Rico with the University of Illinois has shown that the tropical production of soybean is feasible. Not only can the crop be grown throughout the entire year, but yields of 3 to 4 T/Ha have been reported. This tonnage of seed is composed of 40 to 44% protein and approximately 20% oil.

The high yielding potential of many food legumes combined with vast amounts of potentially arable land which is not presently cultivated, tends to provide an optimistic outlook in terms of future food production in the tropics. However, when one reviews and observes the destructive potential of agricultural pests, the outlook is not so bright. The combined natural forces of plant disease (fungi,

bacteria, virus, mycoplasma, and nematodes), insect pests, and weeds present a barrier against increased food production which is extremely difficult to overcome. This applies especially to the less developed regions of the tropics, where climatic conditions favor the continual growth and reproduction of organisms which are harmful to crops. Unless adequate crop protection measures are developed and applied, the use of high yielding cultivars combined with the potential to produce two or three crops a year will not be sufficient to meet the food requirements of the tropical countries.

In the tropical and subtropical regions of the world, where the need for improvement of the human diet is greatest, the soybean will become increasingly important as a source of high quality human food. Towards this end, AID has awarded a seven-year grant (AID/CM/ta-g-73-50) to the University of Puerto Rico. The grant is being used to strengthen the existing competence to provide needed training, research and informational linkages, technical assistance and consultation on major problems related to limiting diseases, weeds and insect pests of soybean and other food legumes for the tropical and subtropical regions of the world. This grant, which emphasizes soybean crop protection, is a companion grant to grant AID/CM/ta-g-73-49 to the University of Illinois at Urbana-Champaign, which concentrates on soybean breeding. These grants have been highly effective in developing the International Soybean Program, INTSOY.

2. Purpose of the Grant

The purpose of this grant, as stated in the original document, is to strengthen the existing competence of the University of Puerto Rico to provide needed training, research and informational linkages, technical assistance and consultation on major problems related to limiting diseases and associated insects and cultural practices of soybeans and other food legumes for tropical and subtropical areas of the world. It is a collaborative grant with the University of Illinois and will utilize the competence, leadership and facilities of the University of Puerto Rico and the University of Illinois.

Following the scheduled 18-month review of the grant program in June 1975, the statement of purpose was slightly modified. It was recommended by the review team that the University of Puerto Rico concentrate it's efforts in the area of crop protection (disease, insect, nematode and weed control) of soybean under tropical conditions. At present, the University of Puerto Rico is continuing to develop a cooperative-interdisciplinary research and advisory team in the area of tropical crop protection of soybean. Research and training efforts are being focused on the production of high quality seed, and the control and management of diseases, weeds and insect pests of soybean. Major emphasis is on the development and dissemination of technology applicable to the small farmer, with the intention of increasing the quantity and quality of human food.

3. Objectives of the Grant

a. Grant objectives focus on the development and improvement of the University of Puerto Rico's institutional response capability in the area of tropical crop protection and production of soybean. The grant emphasizes the development of background knowledge through research and informational linkages in order to provide training, technical assistance and consultation on major problems related to crop protection and production of soybean in the tropical regions of the world. The four major objectives (outputs) of the grant are:

(1) Improved education and training capability. Improvement of the University of Puerto Rico's educational and training capabilities in order to fully utilize and disseminate the knowledge and technology which is generated through the research program or obtained through informational linkages.

(2) Extended knowledge base and research capability. Development of mechanisms which make possible effective, interinstitutional, interdisciplinary research programs in the area of tropical crop protection and production of soybean. Emphasis is placed on the multidisciplinary (teamwork) approach toward solving the major problems related to soybean crop protection in the tropics.

(3) Increased advisory and consulting capability. Development of mechanisms which facilitate effective interdisciplinary advisory and consulting capabilities relative to crop protection and production of soybean in the tropics. Emphasis is placed on the development of a coordinated, interdisciplinary research and advisory team.

(4) Expanded research and informational linkages. Development of a worldwide network of linkages with institutions and individuals which are interested in developing soybean as an important crop for nutrition of human populations in the LDCs of the tropics.

b. Review of objectives

The development of information and technology relative to tropical crop protection of soybean which is applicable to the small farm level in the LDCs is of prime importantce to this program. Relatively little is known about diseases, weeds and insects affecting soybeans in the tropics and methods for their control. Rarely are specific economic control measures available to the farmer. The information base which supports crop protection of soybean in the tropics is entirely inadequate.

The development of human resources is a critical element toward building a U.S. institutional response capability. The development of human resources through graduate education, professional

training, and development of advisory capacity is also of prime importance to the University of Puerto Rico's soybean program. The development of human resources and selected technologies receive the majority of the programs attention and resources.

c. Review of critical assumptions

The world food situation has not significantly changed since the initiation of this grant. The need for high quality protein in order to improve the nutrition and health of the world's poor is still beyond our means. In order for this program to have a significant effect in increasing the world's protein supply through increased production of soybeans in the tropics, several critical assumptions must be met. These assumptions are as follows:

(1) That a two year 211(d) grant extension be awarded to the University of Puerto Rico. The present grant ends on September 30, 1978. The two year extension would finance the program until September 30, 1980. By the year 1980, it is anticipated that continued funding for grant activities will be available through Title XII.

(2) That funding will be made available to the University of Illinois in order to maintain an interinstitutional, cooperative program, with emphasis on developing genetic technology of tropically adapted soybean cultivars.

(3) That future funding for the University of Puerto Rico and the University of Illinois' International Soybean Program (INTSOY) be made available through Title XII or some alternative mechanism of funding by the year 1980.

(4) That AID will provide assistance in the initiation of linkages with tropical LDCs through identifying training needs of institutions and individuals and in exchange of information as part of the linkage network.

(5) It is assumed that U.S. and national LDS institutions will cooperate with the University of Puerto Rico in the initiation and strengthening of linkages, exchanges and visits by staff and students, information exchange and other cooperative activities.

(6) That increasing numbers of students, both from the U.S. and LDCs will be interested in graduate programs and other educational and training activities at the University of Puerto Rico which are relevant to crop protection of soybeans.

Assumptions No. 4, 5 and 6 were sustained in varying degrees during the report period. AID has supported the program to some extent

through identifying certain LDCs which do require technical aid in the area of soybean crop protection and production in the tropics. In addition, AID has given direct cooperation and support in the area of training. Through the office of international training (Mr. Earl B. Terwilliger) the need for specific training in certain areas has been identified and UPR/MC is responding to requests in these areas. The interest of LDCs in supporting graduate students in studying various aspects of soybean crop protection and production at UPR/MC is good. The interest of LDCs in the tropics and subtropics in developing national soybean programs is extremely high. The need and desire to produce soybeans as a source of high quality vegetable protein and oil for human consumption is increasing at a rapid rate; however, the information base which supports production of soybean in the tropics is developing at a much slower rate and, at present, is entirely inadequate, especially in the areas of crop protection, seed production, and seed storage. It will become impossible for any program with highly limited financial support to meet the majority of the requests for technical aid, training and consultation in tropical soybean production and protection.

Assumption No. 1 was sustained in full by AID. AID has granted the University of Puerto Rico a two year grant extension to cover the period from September 17, 1978 to September 16, 1980. The amount of $337,676 has been provided by AID to maintain program continuity for the above mentioned two year period.

The failure to be able to state categorically that assumptions No. 2 and 3 have been or will be sustained could have a debilitating effect on the maintenance and constructive use of the developed institutional response capabilities of both universities. It is hoped that by the year 1980, a continued source of funding will be made available to the International Soybean Program (INTSOY) of UIUC and UPR.

D. Accomplishments

Since the beginning of the grant, UPR/MC has stressed the development of a strong research program in the area of tropical crop protection of soybean and other grain legumes. Following recommendations made by AID personnel in the 18-month review, program emphasis has been placed specifically on soybean. Research on other grain legumes has been continued in the area of seed pathology and production.

The reason for stressing the development of a strong research program is that in order to demonstrate true institutional response capability it is essential to demonstrate the ability and expertise to conduct original research which provides problem solving results. Through conducting original research, staff members provide answers and recommendations for problems which previously were noncontrollable. In addition, staff members gain a true perspective of what the problems are and their importance to tropical soybean production on

a first hand basis. When an institution has demonstrated the ability to conduct research and obtain significant problem solving results, it is then that other countries or institutions (LDCs) will look to that institution for training and consultation in the problem area.

The University of Puerto Rico has developed a strong research program in tropical crop protection of soybean. The program emphasizes the interinstitutional, interdisciplinary, cooperative and coordinated approach toward conducting research. At present, cooperative research is being conducted within and between the fields of plant pathology, seed pathology and production, weed science, plant breeding, soil microbiology and agricultural engineering. The University of Puerto Rico has developed an interinstitutional, interdisciplinary, cooperative and coordinated research team in the area of tropical crop protection of soybean. The research team is also an advisory or consultative team. As requests for aid in consultation or technical training are generated, team members are available to respond to the requests in several disciplines.

Whereas the UPR/MC soybean program will always stress the importance of a strong research program, emphasis is being changed to the development of outreach activities (training, consultation, and publishing) in order to more fully utilize the results obtained through original research and informational linkages and existing staff competence.

Accomplishments for the report period are discussed under five headings: (1) expanded knowledge base and research capability; (2) education and training; (3) advisory capacity; (4) linkages and (5) information capacity.

Output I. Expanded knowledge base and research capability

Most of the work published and research conducted on soybean seed pathology and production, diseases, weed control, insect control, genetics and seed storage is mainly from the temperate zones. Relatively little is known or published in relation to soybean crop protection and pest management in the tropics. In many instances basic information is not available. Rarely are specific, economically feasible control measures available to the small farmer. Thus, the information base which supports the production and protection of soybeans in the tropics is entirely inadequate. On the basis of this rationale, research activities have been initiated with the intention of developing selected technologies in soybean crop protection and production in the tropics. The work presented under this output utilizes the well developed linkages between UIUC and other collaborators. In the cooperative, interinstitutional, multidisciplinary research program, most research activities involve inputs from several scientists in several disciplines.

1. Seed Pathology and the Production of High Quality Seed.

The seed is one of the most basic elements to any legume production

program. Without seed germination and seedling emergence in the field, there is no soybean production. One of the major problems facing increased soybean production in the tropics is a source of high quality, disease free seed for planting. Soybean seed quality problems can be divided into two major problem areas: (1) seed production and (2) seed storage. Problems encountered in the production of high quality seed include: seed infection by microorganisms; damage from pod and seed feeding insects; unfavorable growing conditions for the crop which includes attack from disease, insects and weeds; and unfavorable climatic conditions (rain and high temperatures) at time of harvest. Seed storage problems are mainly due to conditions of high temperature and relative humidity during storage. High temperature and relative humidity are not condusive to long term viability of soybean seed.

Due to the importance of high quality, disease free seed, a significant portion of the UPR/MC research program has been devoted to determining problems related to soybean seed production in the tropics and methods for their control. Research in the area of seed pathology and production includes inputs from the following disciplines: plant pathology; plant breeding; weed science; and agricultural engineering. It is anticipated that future research efforts in the area of seed production will include inputs from entomology as well.

a. Internally seedborne microorganisms of soybean in Puerto Rico

The INTSOY seed pathology culture collection

The soybean seed pathology culture collection was initiated in 1975. The purpose of the collection is to develop and maintain a semi-permanent collection of fungal and bacterial microorganisms which have been found in association with soybeans under tropical conditions. Specimens are maintained on potato dextrose agar in culture tubes. All cultures are covered with sterile mineral oil to insure successful long term storage. In addition, all cultures are transferred to new culture tubes about every six months. Duplicates of any culture in the collection are available to soybean researchers around the world upon request.

The collection will be maintained and increased in the future. At present, the collection consists of the following fungi: *Corynesporia cassiicola*; *Cladosporium* sp.; *Alternaria tenuissima*; *Fusarium semitectum*; *Syncephalastrum* sp.; *Epicoccum* sp.; *Chaetomium* sp.; *Nodulosporium* sp.; *Arthrinium* sp.; *Helminthosporium* sp.; *Curvularia* sp.; *Phoma* sp.; *Trichoderma* sp.; *Sclerotium rolfsii*; *Nigrospora* sp.; *Leptosphaerulina* sp.; *Penicillium* sp.; *Pestalotia* sp.; *Drechslera* sp.; *Phomopsis* sp.; *Glomerella glycines*; *Rhizoctonia solani*; *Lasiodiplodia theobromae*; *Aspergillus flavus*; *Colletotrichum dematium*; *Cercospora kikuchii*; *Rhizopus* sp.; *Tricocladium* sp.; *Macrophoma* sp.; *Gliocladium* sp.; *Macrophomina phaseolina*; *Cephalosporium gregatum*; *Chaetophoma* sp.; *Choanephora* sp.; and *Papularia* sp.

The collection also contains cultures of the following bacteria: *Bacillus subtilis* and *Xanthomonas phaseoli* var. *sojensis*.

b. The effect of incubation temperature on recovery of internally seedborne fungi and germination of pigeon pea seeds.

One of the major factors limiting the increased production of pigeon pea (*Cajanus cajan*) in Puerto Rico is low seed germination and emergence in the field. The field emergence of several commercial plantings in 1976 ranged from 28 to 45%.

In order to better understand the relationship between internally seedborne microorganisms and reduced seed germination and field emergence of pigeon pea, the effect of four incubation temperatures on the incidence of internally seedborne fungi and seed germination in vitro was studied. The experiment was conducted as follows:

Pigeon pea seeds of the cultivars "2B-Bushy", "Line 69-68", and "Kaki" were produced at the Isabela substation of the Puerto Rico Agricultural Experiment Station in the 1976-77 growing season. One poor quality (high percentage of seeds infected by fungi and low percentage germination) seed lot of each cultivar was used in this study. All seeds used for in vitro studies were surface disinfested by soaking in a 0.25% solution of sodium hypochlorite for 2.5 min, then in a 70% solution of ethanol for 2 min, and finally rinsed in sterile distilled water.

Three replications of 100 surface-disinfested seeds per cultivar were plated (four seeds per culture dish) on PDA and incubated at 20, 25, 30 and 35°C. In vitro germination and percent incidence of fungi were recorded for each cultivar and incubation temperature after seven days. The experiment was conducted twice using a completely randomized design. Analysis of variance was performed on all data and means were compared using Duncan's Multiple Range Test (P=.05).

Results of the study were as follows:

The following fungi were isolated from the seeds used in this study; *A. tenuissima*; *Cladosporium* sp.; *F. semitectum*; *L. theobromae* and *Phomopsis* sp. The maxium incidence of total fungi from seeds of all three cultivars was obtained at 25°C (table 1). There was little difference between the percent incidence of total fungi or fungi by genera between 20 and 25°C. At 30°C, the incidence of fungi in general was significantly lower than at 25°C. At 35°C, the recovery of total fungi and fungi by genera for all cultivars was significantly less than at any other temperature.

In vitro germination for all cultivars was lowest at 20 and 25°C (table 1). Germination significantly increased for all cultivars with an increase in incubation temperature from 25 to 30°C. The highest percent germination for all cultivars was obtained at 35°C. For "Line 69-68" and "Kaki", the percent in vitro germination doubled with an increase in incubation temperature from 25 to 35°C.

Table 1. The average percent incidence of total internally seedborne fungi, incidence of fungi by genera and seed germination in vitro for three cultivars of pigeon pea incubated at 20, 25, 30 and 35°C.

Cultivar and incubation temperature °C	Total fungi	Percent fungi by genera[1/]					Germination in vitro
		Alt.	Clad.	Fus.	Lasio.	Phom.	
2B-Bushy							
20	65.0 b[2/]	11.0 a	6.3 a	13.7 a	23.3 a	10.7 b	65.3 c
25	69.3 a	11.3 a	4.3 b	15.0 a	25.7 a	13.0 a	64.7 c
30	41.3 c	4.3 b	2.0 c	9.7 b	20.7 b	4.6 c	76.0 b
35	15.0 d	0.0 c	0.0 d	2.0 c	13.0 c	0.7 d	91.7 a
Line 69-68							
20	80.7 b	6.7 ab	1.0 b	4.3 a	24.7 b	44.0 ab	30.3 d
25	88.7 a	7.7 a	2.7 a	2.7 a	28.0 a	47.7 a	39.3 c
30	80.7 b	5.3 b	0.0 b	2.7 a	29.7 a	43.0 b	48.3 b
35	14.7 c	0.3 c	0.0 b	0.0 b	6.3 c	8.0 c	80.7 a
Kaki							
20	85.3 b	9.7 a	4.0 a	9.7 a	24.7 b	37.3 b	36.0 d
25	98.3 a	10.3 a	3.3 a	10.0 a	30.0 a	44.7 a	40.0 c
30	65.7 c	4.0 b	0.0 b	6.7 b	31.3 a	23.7 c	68.0 b
35	20.7 d	0.0 c	0.7 c	0.7 c	6.3 c	13.7 d	80.0 a

1/ Alt. = *Alternaria tenuissima*, Clad. = *Cladosporium*, Fus. = *Fusarium semitectum*, Lasio. = *Lasiodiplodia theobromae* and Phom. = *Phomopsis* sp.

2/ Means within a column followed by the same letter are not significantly different at the 0.05 level using Duncan's Multiple Range for significance.

When in vitro germination was correlated with the incidence of total fungi, A. *tenuissima*, *Cladosporium* sp., F. *semitectum*; L. *theobromae* and *Phomopsis* sp. the following significant correlation coefficients (0.01 level) were found for cultivar "2B-Bushy", "Line 69-68", and "Kaki", respectively: -.989, -.955, -.885, -.978, -.954 and -.943; -.928, -.918, -.516, -.818, -.851 and -.933; and -.911, -.955, -.926, -.906, -.604 and -.937.

Internally seedborne fungi were associated with reduced germination of pigeon pea seed. As the percent incidence of seedborne fungi increased, the percent germination in vitro decreased for all cultivars tested. All fungal species recovered from seeds were negatively correlated with in vitro germination.

Incubation temperature had a marked effect on recovery of fungi from seeds and seed germination in vitro. By changing incubation temperature from 25 to 35°C, the apparent health of all seed lots tested was significantly improved as expressed by in vitro germination. When seed lots incubated for seven days at 25°C were observed, a high percentage of seeds had not germinated (apparently dead) and were covered by fungal mycelium. With incubation at 35°C, the same seed lot had a significantly lower percentage incidence of seeds showing fungal growth and significantly higher in vitro germination. The germination potential (the actual number of viable seeds of each seed lot) was more accurately recorded at 35°C than at 25°C and the number of seeds infected by fungi was more accurately recorded at 25°C than at 35°C.

c. Studies on the transfer of Technology for controlling seed pathological problems of grain legumes in the tropics.

Increased emphasis on the production of grain legumes in the tropics has led to increased seed pathology related problems. In order to understand and overcome these problems, additional research in the area of seed science will be required. At present, the number of scientists actively conducting research in seed pathology is inadequate, especially in developing countries. Those scientists which are actively involved in seed pathology research are usually confined to one crop or crop type. In view of the importance of tropical seed pathology and technology and the shortage of seed scientists, the complete utilization of research findings is essential.

Research conducted on soybean (*Glycine max* (L.) Merr.), dry bean (*Phaseolus vulgaris* L.) and pigeon pea (*Cajanus cajan* L.) has shown many similarities in seed pathological problems and methods for their control. This suggests that many research findings on specific crops may be directly or indirectly transferred to other crops.

In 1976, research was initiated to determine similarities in seed pathological problems of soybean, cowpea, dry bean and pigeon pea produced under tropical conditions. Experiments have been conducted at the University of Puerto Rico, Mayaguez, to test the feasibility of transferring seed technology between these four leguminous crops.

(1) The effect of delayed harvest date and fungicide sprays on internally seedborne fungi, seed germination and field emergence of four legumes

The transfer experiment was conducted as follows:

Field plots of pigeon pea, dry bean, soybean and cowpea were planted at the same location at the Isabela substation on October 15, 1976. Individual plots consisted of 4-6 m rows on 61-cm centers for each crop. Plots of each crop were treated after pod set by spraying four times at one week intervals with either benomyl (Benlate 50 WP, E. I. du Pont de Nemours and Co., Wilmington, Delaware) (1.14 kg a.i./ha), maneb (manganese ethylenebisdithiocarbamate, Manzate 80 WP, E. I. du Pont de Nemours and Co.) (1.82 kg a.i./ha), maneb + benomyl (0.91 + 0.57 kg a.i./ha, respectively) or maneb + benomyl (1.82 + 1.14 kg a.i./ha, respectively). Sprays were applied with a hand sprayer. Nontreated plots served as controls. Each treatment was replicated four times in a completely randomized block design for each crop.

For all crops, seeds from one row of each sprayed and non-sprayed plot were harvested at maturity (first harvest). One of the remaining three rows per plot was harvested at 1, 2 and 3 weeks after maturity (delayed harvests). All seeds were dried to 12-13% moisture and stored at 10°C until assayed in the laboratory or planted in the field.

The experiment was planted a second time at the Isabela substation on July 11, 1977. Mixtures of benomyl + maneb were not included among the treatments in the second year of the experiment. All other procedures were as previously described.

For all crops, one-hundred seeds from each replication per treatment and harvest date for both plantings were bioassayed for incidence of internally seedborne fungi and percentage germination in-vitro. All seeds were surface-disinfested by soaking in a 0.25 percent sodium hypochlorite solution for 2.5 minutes, followed by 70 percent ethanol for 2 minutes, and finally rinsed in sterile distilled water. Seeds were then plated on Gibco potato dextrose agar (PDA) in culture dishes. The percentage of germination and incidence of fungi were recorded after 7 days at 25°C. A seed was considered germinated when the radicle was 1.5 times the length of the cotyledons.

An additional 100 seeds from each replication per treatment and harvest date for both dates of planting were planted in the field at the Isabela substation. Seeds were planted in 3 m rows on 61-cm centers in a completely randomized block design. Emergence in the field was recorded after 20 days. Analysis of variance was conducted on all data.

Results from the study are as follows:

Internally seedborne fungi

The following genera of fungi were recovered from seeds of all four crops: *Alternaria tenuissima*; *Fusarium semitectum*; *Lasiodiplodia theobromae*; and *Phomopsis* sp. The internally seedborne fungi were almost identical for all four crops.

The percentage seed infection by these fungi significantly increased with time in the field past maturity for all crops tested (tables 2, 3, 4, 5). Foliar applications of benomyl significantly reduced the increased seed infection by all fungi (except A. *tenuissima*) which accompanied delayed harvest in all crops tested. Maneb alone appeared to have no or very little effect on controlling seed infection by fungi in the field for all crops.

Germination and field emergence

At maturity, all treatments for all crops had good seed quality (over 85% germination). The percentage seed germination and field emergence for all treatments and crops was significantly reduced with a delay in harvest date past maturity (tables 2, 3, 4, 5). The trends in reduced seed germination and field emergence were almost identical for each crop tested. Seeds from plants treated with benomyl maintained a higher germination percentage than seeds from plants treated with maneb and the non-treated control. For all crops, there were little or no differences in seed germination and field emergence between seeds from plants sprayed with maneb and the nontreated control.

The results of this study demonstrate the many similarities in seed pathological problems of grain legumes in the tropics. Not only was the internally seedborne fungal microflora of each crop almost identical, but the methods tested for controlling them gave almost identical results for each crop. The concept of transfer of technology in the seed production of grain legumes appears to have promise. This study has demonstrated two methods for controlling seed infection by fungi which are directly transferable between all legumes tested. Harvesting seed production fields immediately at maturity is extremely important in

the production of high quality seeds. This probably applies to all of the food legumes. The importance of timely harvest is one example of knowledge which we now have that could be directly applied to all seed crops in the tropics.

At times it is impossible to harvest at maturity. Wet weather at the time of harvest has resulted in four to six week delays in harvest of soybeans in Illinois and Indiana. Under situations such as these, the use of foliar fungicides may be beneficial in maintaining higher seed quality until the harvest can be made. The results of this study suggest that the use of fungicides is another bit of technology which could be directly transferred between grain legumes in the tropics. The application of fungicides is often limited by economics; however, in problem situations and if applied only to seed production fields, their use may be economically feasible on a number of different crops.

In order to fully utilize the results of tropical seed pathology research, the concept of transfer of technology should be studied further.

Table 2. Mean percentage germination in culture plates (Germ.), field emergence (Emerg.) and total percentage of seeds with internally seedborne (Fungi) of soybean from plants sprayed with maneb or benomyl alone and in combination during 1976 and harvested at four weekly intervals beginning at maturity.

Treatment and Rate in kg a.i/ha[a/]	Harvest after maturity (in weeks)	Mean percentage[b/]		
		Germ.	Emerg.	Fungi
Maneb (1.82)	0	99.0	87.7	9.0
	1	90.0	82.2	16.7
	2	78.0	67.5	36.7
	3	49.0	37.0	91.3
Benomyl (1.14)	0	99.0	95.5	2.0
	1	97.0	93.0	4.2
	2	95.5	91.7	21.7
	3	78.5	78.0	53.7
Maneb (0.91) + Benomyl (0.57)	0	99.5	96.2	2.0
	1	98.5	92.5	4.2
	2	94.0	89.0	20.5
	3	81.0	80.0	58.5
Maneb (1.82) + Benomyl (1.14)	0	98.5	96.7	1.5
	1	97.0	93.5	4.0
	2	95.5	92.0	22.0
	3	82.5	80.2	56.8
Nontreated	0	98.5	89.0	9.5
	1	88.5	84.0	15.0
	2	77.0	69.2	34.5
	3	51.0	33.2	89.0
LSD (.05) - Between harvests within treatments =		2.57	5.13	2.76
- Between treatments within harvests =		2.53	5.16	2.95

a/ Benomyl = methyl 1 (butylcarbamoyl-2-benzimidazolecarbamate as Benlate 50 WP; maneb = manganese ethylenebisdithiocarbamate as manzate 80 WP; a.i. = active ingredient.

b/ Based on four replications of 100 seeds from each treatment and harvest date.

Table 3. Mean percentage germination in culture plates (Germ.), field emergence (Emerg.) and total percentage of seeds with internally seedborne (Fungi) of pigeon pea from plants sprayed with maneb or benomyl alone and in combination during 1976 and harvested at four weekly intervals beginning at maturity.

Treatment and Rate in kg a.i/ha[a/]	Harvest after maturity (in weeks)	Germ.	Emerg.	Fungi
Maneb (1.82)	0	88.7	75.7	29.7
	1	77.5	67.0	58.5
	2	60.8	57.3	76.2
	3	54.8	51.0	91.5
Benomyl (1.14)	0	91.7	85.5	21.0
	1	88.0	87.0	33.5
	2	83.2	83.7	52.5
	3	73.7	70.0	75.5
Maneb (0.91)	0	93.2	89.0	19.8
+	1	87.7	87.7	34.3
Benomyl (0.57)	2	83.0	84.5	52.0
	3	71.3	72.3	75.0
Maneb (1.82)	0	92.7	88.3	19.8
+	1	86.7	87.7	34.0
Benomyl (1.14)	2	82.3	84.2	54.0
	3	73.7	74.5	74.8
Nontreated	0	87.8	73.5	30.8
	1	77.7	65.5	61.5
	2	59.5	55.8	75.3
	3	52.3	48.5	91.5
LSD (.05) - Between harvests within treatments =		2.86	2.41	3.99
- Between treatments within harvests =		2.96	3.65	3.81

a/ Benomyl = methyl 1 (butylcarbamoyl-2-benzimidazolecarbamate as Benlate 50 WP; maneb = manganese ethylenebisdithiocarbamate as manzate 80 WP; a.i. = active ingredient.

b/ Based on four replications of 100 seeds from each treatment and harvest date.

Table 4. Mean percentage germination in culture plates (Germ.), field emergence (Emerg.) and total percentage of seeds with internally seedborne (Fungi) of dry bean from plants sprayed with maneb or benomyl alone and in combination during 1976 and harvested at four weekly intervals beginning at maturity.

Treatment and Rate in kg a.i/ha[a/]	Harvest after maturity (in weeks)	Mean percentage[b/]		
		Germ.	Emerg.	Fungi
Maneb (1.82)	0	89.7	90.0	21.0
	1	73.5	70.0	39.5
	2	64.0	59.2	60.7
	3	48.7	43.5	87.2
Benomyl (1.14)	0	98.2	93.0	10.2
	1	95.7	95.0	28.2
	2	88.2	89.0	54.7
	3	73.5	72.0	84.2
Maneb (0.91) + Benomyl (0.57)	0	98.7	97.0	5.7
	1	96.2	95.2	23.5
	2	91.5	87.7	57.7
	3	74.0	72.0	83.0
Maneb (1.82) + Benomyl (1.14)	0	99.5	96.5	4.5
	1	98.0	95.5	22.2
	2	94.5	89.7	60.5
	3	79.0	74.0	83.2
Nontreated	0	85.7	84.7	23.0
	1	69.0	68.2	43.7
	2	58.5	57.7	63.3
	3	43.5	40.0	94.9
LSD (.05) - Between harvests within treatments =		2.92	3.26	4.49
- Between treatments within harvests =		3.71	3.63	4.22

a/ Benomyl = methyl 1 (butylcarbamoyl-2-benzimidazolecarbamate as Benlate 50 WP; maneb = manganese ethylenebisdithiocarbamate as manzate 80 WP; a.i. = active ingredient.

b/ Based on four replications of 100 seeds from each treatment and harvest date.

Table 5. Mean percentage germination in culture plates (Germ.), field emergence (Emerg.) and total percentage of seeds with internally seedborne (Fungi) of cowpea from plants sprayed with maneb or benomyl alone and in combination during 1976 and harvested at four weekly intervals beginning at maturity.

Treatment and Rate in kg a.i/ha[a/]	Harvest after maturity (in weeks)	Germ.	Emerg.	Fungi
Maneb (1.82)	0	95.2	97.2	14.5
	1	85.0	85.0	34.5
	2	77.7	78.7	62.5
	3	67.0	70.0	96.0
Benomyl (1.14)	0	99.5	96.7	5.2
	1	97.0	95.7	14.2
	2	94.0	91.7	40.2
	3	90.0	85.0	79.0
Maneb (0.91)	0	99.5	99.0	4.0
+	1	99.0	96.0	12.2
Benomyl (0.57)	2	95.0	93.0	38.7
	3	88.0	84.5	78.5
Maneb (1.82)	0	100.0	98.5	3.5
+	1	98.2	94.2	11.7
Benomyl (1.14)	2	93.0	92.5	39.2
	3	90.0	85.7	79.0
Nontreated	0	95.5	93.5	13.5
	1	83.0	82.7	33.2
	2	76.5	76.0	62.0
	3	67.7	66.7	97.0
LSD (.05) - Between harvests within treatments =		2.06	3.07	2.16
- Between treatments within harvests =		2.21	3.40	2.43

a/ Benomyl = methyl 1 (butylcarbamoyl-2-benzimidazolecarbamate as Benlate 50 WP; maneb = manganese ethylenebisdithiocarbamate as manzate 80 WP; a.i. = active ingredient.

b/ Based on four replications of 100 seeds from each treatment and harvest date.

d. Effect of genotype on internally seedborne fungi and germination of soybean - selection and breeding for good seed quality characteristics.

The most direct method of eliminating seed production problems at the small farm level in tropical LDCs is to develop tropically adapted soybean cultivars which have inherent good seed quality characteristics. Resistance to seed infection by fungi in adapted cultivars would greatly increase the chances of a small farmer to produce high quality seed, even under adverse growing conditions.

Research was initiated in 1975 to improve seed quality characteristics of tropically adapted soybean cultivars through interdisciplinary research in plant breeding and plant pathology. The research has been focused on the detection of genetic differences in the incidence of soybean seed infection by fungi in the field. In addition, the detection and selection of cultivars which maintain a high percentage seed germination under adverse growing conditions (delayed harvest) has also been a major objective of the project.

The results of an initial screening for seed quality in 1975 and results of the seed quality evaluation conducted on 24 lines selected from the original screening have been reported in previous annual reports. The results obtained to date indicate that there is considerable genetic variation for seed quality characteristics under tropical conditions, and that progress in improving or incorporating these characteristics into high yielding cultivars may be possible. In order to study the inheritance of good seed quality characteristics, crosses have been made using superior seed quality lines "PI 219.653", "PI 204.331", and "PI 205.908" in combination with "Hardee Late Selection" and "Jupiter". The results of these inheritance studies will be reported at a later date.

(1) Effect of pod inoculation with *Phomopsis* sp. on seed germination of two soybean cultivars.

Based on the results of the seed quality evaluation trial, which was conducted in 1976, and 1977, the cultivars "PI 205.912" and "Hardee" were selected for use in this study. "PI 205.912" has shown good seed quality characteristics (high viability and low incidence of fungi) under delayed harvest conditions. "Hardee" has shown poor seed quality characteristics (low viability and high incidence of fungi) under identical conditions. Both cultivars reached maturity at the same time (109 days). Attached pods of both cultivars were inoculated in the greenhouse at four different stages of development with isolates of *Phomopsis* sp. recovered from infected soybean seeds. Pods were inoculated by immersion in a suspension of mycelium and spores of *Phomopsis* sp. Noninoculated pods served as controls. All pods were harvested at one week after maturity and their seeds assayed for incidence of *Phomopsis* and germination in-vitro. The objective of the study was to detect varietal differences in the rate and/or effect of seed infection by *Phomopsis* sp.

Results of the study were as follows:

Phomopsis was not recovered from seeds of noninoculated pods of either cultivar. The mean percentage seed infection and germination in-vitro of seeds from inoculated pods of "PI 205.912" was 61 and 71%, respectively, and 67 and 11%, respectively, for Hardee (Table 6). The percentage seed germination in-vitro of seeds from noninoculated pods of "PI 205.912" and "Hardee", respectively, was 88 and 79%. There was no significant difference in the incidence of *Phomopsis* in seeds from inoculated pods of both cultivars; however, seeds of "PI 205.912" which were infected by *Phomopsis* had a significantly higher in-vitro germination percentage than infected seeds of Hardee. This data suggests that "PI 205.912" may posses some form of tolerance against seed or seedling death incited by *Phomopsis* sp. The results of this study are very encouraging in that they indicate that varietal differences in the effect of seed infection by *Phomopsis* do exist. Program funding will be used in order to conduct future research directed toward further study of seed quality differences and the incorporation of good seed quality characteristics into high yielding, tropically adapted cultivars.

Table 6. Percentage of seeds infected by *Phomopsis* sp. and percentage germination in-vitro (PDA) of soybean seeds from pods of two cultivars inoculated with *Phomopsis* sp. at four stages of maturity in the greenhouse.

		Green-seeds not expanded		Green-seeds fully expanded		Yellowing		Mature	
		PI[1/]	H	PI	H	PI	H	PI	H
Phomopsis sp.									
	Inoculated	86[2/]	94	79	83	46	48	33	44
	Noninoculated	0	0	0	0	0	0	0	0
Germination									
	Inoculated	80	16	83	20	70	6	50	4
	Noninoculated	85	82	84	79	92	78	89	76

1/ PI = PI-205.912

H = Hardee

2/ Based upon the seeds obtained from 30 pods.

(2) Continued evaluation of seed quality characteristics in tropically adapted soybean germplasm.

The preliminary screening of groups XIII, IX and X for good seed quality characteristics has been previously reported. Several cultivars in the preliminary screening looked promising; however, only 24 were selected for additional testing in a replicated field trial (the results of which have also been previously reported). In order not to overlook other promising lines, 84 additional cultivars from groups VIII, IX and X which look promising in the preliminary screening were selected for this study.

Six meter rows of each cultivar were planted at the Isabela substation in July 1977. The planting was randomized and there were two replications for each cultivar. At maturity, one half of each row was harvested. The remaining half row was harvested after three weeks (delayed harvest). Fifty seeds from each replication per cultivar and harvest date were assayed in the laboratory for incidence of internally seed-borne fungi. One hundred seeds from each replication per cultivar and harvest date were tested for germination percentage in a seed germinator at 30°C.

Results of the screening were as follows:

A great deal of variation was observed in seed quality characteristics for the 84 cultivars tested (table 7). Most cultivars had good seed quality (high percentage germination) when harvested at maturity. This agrees with previous reports and emphasizes the importance of timely harvest in the production of high quality soybean seed. Under adverse conditions of delayed harvest, many cultivars rapidly lost seed viability. The cultivars "Hardee" and "Jupiter" were included in the trial as controls. The percentage germination of "Hardee" and "Jupiter" after a three week delay in harvest date was 6 and 26%, respectively. Many of the selected cultivars maintained a percentage seed germination of over 80% under identical conditions. It should be noted that conditions at the time of harvest were not condusive to production of high quality seed. Rainfall was recorded almost every other day under delayed harvest conditions. The fact that several cultivars still maintained good seed quality (over 80% germination) under these adverse conditions is extremely encouraging.

It is hoped that the good seed quality cultivars which have been identified in the screening trials at UPR will be examined more closely in national breeding programs of the LDCs. If good seed quality characteristics can be incorporated into locally adapted cultivars, a great deal can be accomplished toward alleviating problems associated with the production of high quality soybean seeds under tropical conditions.

Table 7: Soybean Seed Quality Evaluation - 1977

Entry	First Harvest[1/] Germ.[3/] S. G.	First Harvest Germ.[4/] PDA	First Harvest Total Fungi	First Harvest Phom.	Second Harvest[2/] Germ. S. G.	Second Harvest Germ. PDA	Second Harvest Total Fungi	Second Harvest Phom.
1. 85.897	65	77	29	11	43	39	70	60
2. 159.922	80	74	78	54	38	34	88	60
3. 159.925	86	84	20	10	9	13	71	33
4. 175.177	88	90	18	4	17	11	69	28
5. 181.696	93	92	3	1	88	85	57	47
6. 181.697	94	90	4	1	91	84	65	52
7. 181.698	91	90	7	1	52	50	57	33
8. 183.900	89	93	5	1	79	77	50	23
9. 203.398	91	93	3	2	74	39	70	35
10. 203.400	78	84	16	8	39	45	67	24
11. 204.337	89	93	2	2	77	78	42	22
12. 204.339	94	92	2	0	31	32	83	64
13. 204.340	90	89	19	9	78	72	56	24
14. 205.909	91	89	14	3	73	75	19	10
15. 205.911	94	91	5	1	85	84	61	15
16. 205.913	94	93	20	5	92	87	58	21
17. 205.914	93	93	7	1	89	84	69	24
18. 208.434	92	88	12	4	27	30	81	45
19. 209.340	81	86	43	36	55	53	73	57
20. 209.837	80	76	41	20	7	4	93	72
21. 210.178	96	90	14	5	87	83	34	18
22. 222.547	92	91	3	0	84	80	57	28
23. 222.548	--[5/]	--	--	--	--	--	--	--
24. 222.550	95	95	4	1	85	84	59	20
25. 224.268	13	21	63	59	1	4	93	64
26. 239.237	94	93	1	1	87	82	44	19
27. 240.666	91	95	1	0	69	62	61	40
28. 259.538	98	96	2	1	84	83	33	18
29. 259.540	93	94	9	3	88	85	61	16
30. 259.543	90	91	8	0	88	85	43	18
31. 262.180	72	81	27	22	29	28	70	56
32. 274.507	82	88	24	15	76	73	60	49
33. 281.888	90	91	17	9	80	73	60	40
34. 284.814	93	92	7	1	75	71	66	42

Table 7: Soybean Seed Quality Evaluation - 1977

Entry	First Harvest[1] Germ.[3] S. G.	First Harvest[1] Germ.[4] PDA	First Harvest[1] Total Fungi	First Harvest[1] Phom.	Second Harvest[2] Germ. S. G.	Second Harvest[2] Germ. PDA	Second Harvest[2] Total Fungi	Second Harvest[2] Phom.
35. 323.564	81	84	16	10	42	45	78	67
36. 324.068	56	60	78	39	50	51	86	49
37. 331.793	92	93	4	1	57	41	66	41
38. 331.795	37	36	71	47	27	36	88	60
39. 376.845	82	84	12	3	88	81	63	27
40. 374.155	91	89	38	16	90	85	51	22
41. 374.159	88	91	10	2	83	85	69	25
42. 374.161	90	82	30	18	73	70	70	32
43. 373.162	92	91	25	16	74	71	65	21
44. 374.163	95	94	2	1	90	86	50	21
45. 374.165	94	97	1	0	72	69	70	32
46. 374.166	94	94	8	2	82	84	47	21
47. 374.173	90	90	33	19	--	--	--	--
48. 374.180	89	91	46	30	29	32	88	73
49. 374.181	90	91	33	24	79	82	36	19
50. 374.182	90	90	43	27	31	37	89	66
51. 374.183	90	92	41	25	84	85	40	20
52. 374.186	95	93	14	7	88	77	58	30
53. 165.524	92	91	12	4	87	83	56	22
54. 205.902	90	94	5	1	87	85	57	30
55. 259.542	89	87	35	22	23	31	90	58
56. 307.597	92	87	40	26	82	84	73	26
57. 307.891	93	91	20	8	70	63	69	44
58. 309.655	92	92	14	4	84	79	40	25
59. 323.563	88	93	13	6	80	75	62	28
60. 324.187	85	91	6	1	65	55	78	43
61. 340.899	88	91	55	18	83	81	48	20
62. 340.900	89	89	16	8	70	59	78	43
63. 341.241	80	87	6	2	66	61	80	43
64. 341.246	94	93	17	5	90	83	35	20
65. 341.251	87	86	38	19	29	30	82	64
66. 341.257	85	88	7	2	--	--	--	--
67. 215.688	82	80	64	25	39	41	82	60
68. 261.272	84	87	38	21	40	32	66	50

Table 7: Soybean Seed Quality Evaluation - 1977

Entry	First Harvest[1/]				Second Harvest[2/]			
	Germ.[3/] S. G.	Germ.[4/] PDA	Total Fungi	Phom.	Germ. S. G.	Germ. PDA	Total Fungi	Phom.
69. 274.453	--	--	--	--	--	--	--	--
70. 281.897	93	93	30	5	86	83	41	22
71. 281.909	83	90	34	18	21	27	82	61
72. 307.896	--	--	00	--	--	--	--	--
73. 340.904	95	91	21	8	69	81	51	4
74. 341.254	96	95	2	0	91	85	49	16
75. 341.258	91	90	50	19	72	69	60	45
76. 374.188	--	--	--	--	--	--	--	--
77. 374.191	--	--	--	--	--	--	--	--
78. 374.198	--	--	--	--	--	--	--	--
79. 374.204	--	--	--	--	--	--	--	--
80. 219.653	93	93	5	2	84	82	39	25
81. 204.331	69	77	56	25	23	25	86	68
82. 205.912	88	92	9	2	79	76	43	25
83. Jupiter	51	57	61	35	19	26	93	70
84. HLS	41	45	74	40	9	6	100	76

1/ First harvest = harvested at physiological maturity.

2/ Second harvest = harvested 3 weeks after physiological maturity.

3/ Germ. S. G. = Germination in germinator based on 2 rep. of 100 seeds incubated at 30°C.

4/ Germination on PDA, total fungi and Phomopsis based on 2 rep. of 50 seeds incubated at 25°C.

5/ Missing data.

e. Effect of fungicide seed treatment on the field emergence of soybean in the tropics.

The use of fungicides in developing countries (LDCs) is generally considered to be highly limited due to economic factors. In contrast with foliar applications of fungicides, the use of fungicide for seed treatment is very inexpensive. The recommended rate for most seed treatment fungicides is 2 to 4 ounces per bushel or 100 pounds of seed.

Research conducted under this grant has demonstrated that fungicide seed treatment is beneficial in increasing the field emergence of poor quality (high percentage of seed infected by fungi and low percentage seed germination) seed of several grain legumes in the tropics. When it becomes necessary to use seed of poor or marginal quality for planting, fungicide seed treatment may prove to be economically feasible, even at the small farmer level in tropical LDCs.

During the reporting period, a seed treatment trial was conducted using four soybean cultivars of varying seed quality. Seed quality of the four cultivars ranged from excellent to extremely poor. The results of the trial are as follows (table 8):

Poor quality (below 70% germination) seeds of the soybean cultivars 'UFV-1', 'Jupiter' and 'GH-31-8-2' were harvested in 1977 from plants grown at the Lajas Experiment Station, University of Puerto Rico. Good quality (above 90% germination) seeds of the cultivar 'CH3' were harvested in 1978 from plants grown at the Isabela Experiment Station, University of Puerto Rico. Seeds from each cultivar were bioassayed before treatment for presence of internally seedborne fungi and germination in-vitro. Three replications of 100 seeds per cultivar were surface disinfested and placed on sterile potato dextrose agar. Incidence of internally seedborne fungi and germination in-vitro were recorded after 7 days at 25°C. The percent internally seedborne fungi and in-vitro germination for cultivars 'UFV-1', 'Jupiter', 'GH-31-8-2' and 'CH3', respectively, were: 69, 47; 42, 67; 86, 22 and 8, 95. Internally seedborne fungi for all cultivars consisted mainly of *Alternaria* spp., *Fusarium* spp. and *Phomopsis* spp. Seeds of each cultivar were treated in 100-seed lots on August 28, 1978 and planted 4 days later at the Isabela Experiment Station. Treatments were arranged in a completely randomized design with 3 replications of 100 seed per each 6 m row. Stand counts were recorded at 15 days after planting.

Except for Mertect on seeds of 'UFV-1', all treatments significantly increased the percent field emergence over the nontreated control for the three poor quality seed lots ('UFV-1', 'Jupiter' and 'GH-31-8-2'). There were no significant differences in percent field emergence between any treatments and the nontreated control for the good quality seed lot ('CH3'). Phytoxicity was noted on seedlings treated with Mertect at both rates tested. Mertect phytoxicity was observed as a marginal necrosis on cotyledons of seedlings from seeds treated at the rate of 4 oz/bu and as a marginal chlorosis on cotyledons of seedlings from seeds treated at the rate of 2 oz/bu.

Table 8: INTSOY - 1978 soybean seed treatment trial.

Treatment and rate	Mean stand count at 15 days[1]			
	UFV-1	Jupiter	GH-31-8-2	CH3
Arasan 50 Red 4 oz/bu	58.3 a	81.0 a	41.3 ab	92.6 a
Arasan 50 Red 2 oz/bu	58.0 ab	79.0 a	35.6 bc	92.0 a
Orthocide 75 WP 2 oz/bu	57.0 abc	70.6 b	34.6 bcd	93.0 a
Zinc Omadine 4 oz/bu	62.3 a	80.0 a	46.3 a	92.0 a
Tecto 10 4 oz/bu	50.0 cde	68.3 b	26.0 ef	92.3 a
Tecto 10 2 oz/bu	51.0 bcd	67.3 b	29.3 def	92.3 a
Tecto 10 2 oz/bu + Arasan 50 Red 2 oz/bu	60.0 a	79.0 a	33.0 cde	92.0 a
Mertect 340-F 4 oz/bu	45.0 de	65.6 b	22.3 f	92.0 a
Mertect 340-F 2 oz/bu	43.6 ef	63.3 b	21.6 f	91.3 a
Nontreated control	38.3 f	60.3 c	11.0 g	91.0 a

[1]Similar letters indicate Duncan's multiple range groupings of treatments which do not differ significantly at the .05 level.

f. Studies on the use of low level technology for seed storage of grain legumes in the tropics.

Once high quality seeds have been produced, they then have to be successfully stored until the crop is planted. Tropical conditions of high temperature and relative humidity are not condusive to the maintenance of soybean seed viability. Soybean seed storage (maintenance of viability) is a serious problem in the tropics. If the tropical production of soybean is to be increased, practical methods of seed storage must be developed and applied. Present facilities and economical situations in most LDCs of the tropics may limit the practical use of cold storage. Therefore, alternate seed storage methods are being sought.

The International Soybean Program (INTSOY) has been conducting research on soybean seed storage in the tropics since 1975. This storage work has been a cooperative effort between the Department of Agricultural Engineering and the Department of Crop Protection at UPR/MC and UIUC.

Major emphasis has been placed on the identification of factors which inhibit successful seed storage in the tropics, and the use of low level technology in seed storage methods.

Research which has been conducted thus far indicates that two major factors affecting soybean seed storage in the tropics are initial moisture content of the seed and relative humidity in the storage environment. Results of the first seed storage experiment were presented in the 1975-76 annual report. The results showed that the viability of high quality seed declined rapidly to almost zero after six months of improper storage in a tropical environment. The loss of seed viability appeared to be closely associated with a marked gain in seed moisture during storage. Containers resistant to moisture vapor transmission tended to preserve seed quality. Drying soybean seed to a safe moisture content was shown to be of little value if no effort was made to prevent moisture gain during storage. The moisture content of unprotected seed approached equilibrium with the humid atmosphere of the tropical environment. Reducing the seed moisture content and maintaining it during storage were shown to be essential ingredients for preserving seed quality at an acceptable level for nine months storage in the tropics. Sealed metal containers or plastic bags placed in metal containers with covers offered adequate storage protection for seed with a low initial moisture content.

In a second phase of the seed storage work, the effect of seedborne microorganisms on soybean seeds stored under tropical conditions was of primary concern. Results of the second phase of research were almost identical to those of the first phase. The rapid loss of seed viability in storage was directly related to percentage moisture level of the seed and time in storage. The best containers for storage were those that maintained a low initial moisture content throughout the storage period.

In the studies conducted thus far, seedborne fungi have not appeared to play a major role in reducing seed viability in storage. The recovery of total internally seedborne fungi has been observed to decrease with time in storage. In addition, fungicide seed treatment had no affect on seed storability.

The incidence of seedborne *Bacillus* sp. has been significantly and negatively correlated with decreased soybean seed viability in storage. *Bacillus* sp. may play some role in reducing soybean seed viability in storage.

From a practical point of view, the best method of controlling increased populations of seedborne microorganisms and decreased seed viability in storage is to maintain a storage environment which does not permit the growth of pathogens and provides maxium conditions for maintaining seed viability. Research conducted to date indicates that this type of environment can be obtained by drying the seeds to a low initial moisture content (below 12%) and placing them in an air-tight container which will maintain that moisture content.

Future research in the area of seed storage will concentrate on the development of a simple storage container that will maintain initial moisture content and can be used at the small farm level in tropical LDCs.

(1) The effect of initial seed moisture content and container type on pigeon pea seed viability in storage.

In order to confirm the results of previous storage experiments the following experiment was conducted using pigeon pea (*Cajanus cajan*) as a test crop. Pigeon pea was selected for use in this study because of their economic importance to Puerto Rico. At present, long term storage of pigeon pea seed is a considerable problem facing Puerto Rican agriculture.

The experiment was conducted as follows:

Seeds used in this study were harvested on March 15, 1977 from a five hectare field of pigeon pea (cultivar "2B-Bushy") at the Fortuna Substation, Agricultural Experiment Station, University of Puerto Rico. Three samples of 400 seeds were tested for percentage incidence of seedborne fungi and germination in-vitro [potato dextrose agar (PDA)]. This assay was conducted in order to determine initial seed quality. All seeds were treated at the rate of 113 g product/45 kg seed with the insecticide thiodan [6,7,8,9,10,10-hexachloro- 1, 5, 5a, 6, 9, 9a-hexahydro-6, 9-methano-2, 4, 3-benzo (3)-dioxathiepin-3-oxide]. Insecticide treated seeds were divided into lots of 3.5 kg and adjusted to either 9, 13, or 17% moisture content (dry weight basis). Seed lots at each moisture content were than placed in cotton cloth bags or sealed in plastic (polyethylene) bags with a thickness of .0012 cm. Plastic bags were sealed with plastic tape and care

was taken to make sure that bags were air tight. Seed lots at all moisture contents and in both storage containers were placed either under ambient conditions at Mayaguez or in cold storage (13°C) at the Lajas substation on March 25, 1977.

At two month intervals up to one year, seeds from all treatments were tested for percentage incidence of seedborne fungi, germination in-vitro, emergence in sand, and moisture content. Three samples of 100 seeds from each lot were surface disinfested by soaking in a 0.25% solution of sodium hypochlorite for 2.5 min, then in a 70% solution of ethanol for 2 min, and finally rinsed in sterile distilled water. Surface disinfested seeds were then placed on sterile PDA (4 seed per culture dish) and incubated at 25°C. After 7 days, the percentage in-vitro germination and incidence of seedborne fungi was recorded. Three samples of 100 seeds from each lot were also planted in a sandbench at the Isabela substation. Percentage emergence in sand was recorded after 14 days. The percentage moisture content of each lot was measured using a Dicky John seed moisture tester which was equilibrated for use on pigeon pea. After one year of storage three replications of 100 seeds from each treatment were planted in the field at the Isabela Substation. One hundered seeds were planted in 3 m rows on 65 cm centers in a completely randomized design. Field emergence was recorded after 21 days.

Results were as follows:

The seeds used in this study were of high quality prior to being placed in storage. The mean percentage in-vitro germination prior to storage was 94% with 15% of the seeds containing internally seedborne fungi.

The initial moisture content of all seeds stored in air-tight plastic bags was maintained at plus or minus .5% for one year. Seeds placed in cloth bags under ambient and cold storage conditions equilibrated to 16.5 and 13.5%, respectively, after 4-months storage, and maintained this moisture content (plus or minus .5%) for one year.

For all treatments in cold storage, and seeds at 9 and 13% moisture sealed in plastic bags and stored under ambient conditions, there were no significant differences in either the percent seed germination in-vitro or emergence in sand when comparing the 2-month and 12-month sampling dates. All of the above mentioned treatments had at least 90% germination in-vitro and 88% emergence in sand after 12-months storage (table 8). All treatments stored in cloth bags under ambient conditions had no significant differences in percent in-vitro germination or emergence in sand after 2-months storage. Germination in-vitro and emergence in sand significantly decreased for all treatments in cloth bags under ambient conditions for each sampling date beginning at 4 months.

There was a significant decrease in percent in-vitro germination and emergence in sand at all sampling dates up to 10-months for seeds at 17% moisture in sealed plastic bags stored under ambient conditions. After 10-months, all seeds at 17% moisture in sealed plastic bags under ambient conditions were dead.

Seedling emergence in the field after 12-months storage was considerably lower than emergence in sand or germination in-vitro for all treatments (table 8). There were no significant differences in percent field emergence between all treatments in cold storage and 9 and 13% moisture in sealed plastic bags under ambient conditions after 12-months storage. The percent field emergence for these treatments ranged from 68 to 72% after 12 months. Seeds from all treatments stored in cloth bags under ambient conditions had significantly less emergence in the field than the previously mentioned treatments. There was no significant difference in percent field emergence between any treatments stored in cloth bags under ambient conditions. The percent field emergence for all seeds stored in cloth bags under ambient conditions ranged from 16 to 19%. Seeds at 17% moisture in plastic bags under ambient conditions did not emerge in the field. The reduction in percent field emergence below percent emergence in sand and germination in-vitro cannot be explained from the results of this study, but is probably due to unfavorable field conditions for seedling emergence.

Seedborne fungi have been associated with decreased seed germination in storage. In this study, seedborne fungi were not associated with reduced seed germination. The initial percentage of seeds infected by fungi was low (15%). The percent incidence of seedborne fungi significantly decreased for all treatments between the 2 and 12-month sampling dates. No treatment had over 2% incidence of seedborne fungi after 12-months storage. A bacterium resembling *Bacillus subtilis* was associated with all dead seeds observed in this experiment. *Bacillus subtilis* has been reported to be associated with reduced seed viability of soybean in storage.

Seed moisture content and storage temperature are critical factors in the long term (one year) storage of pigeon pea seed. When seed moisture content was adjusted (dried) to 9 and 13%, then maintained at that level by placement in an air-tight container, seeds were successfully (germination in-vitro maintained at 90%) stored for one year under ambient conditions at Mayaguez. Seeds at high moisture content (over 13%) lost viability rapidly under ambient conditions. When seeds with over 13% moisture were placed in cold storage (13°C), they were successfully stored for one year.

The results of this study indicate that successful seed storage of pigeon pea can be accomplished without conditioned

(dehumidified and refrigerated) storage. Low level technology can be employed in seed storage. The elimination of dehumidification and refrigeration equipment could result in reduced storage costs and a reduction in problems associated with equipment maintenance.

Table 8. Effect of seed moisture content, storage container, storage environment, and time on percent seed germination *in-vitro* (PDA), emergence in sand and field emergence of Pigeon Pea.

Storage[1/] Treatment	Percent[2/] seed germination *in-vitro* (GI), emergence in sand (E) and field emergence (FE) at various sampling times in months (mo).												
	2 mo.		4 mo.		6 mo.		8 mo.		10 mo.		12 mo.		
	GI	E	GI	E	GI	E	GI	E	GI	E	GI	E	FE
9-A-C	95	93	93	88	72	66	63	59	53	50	37	32	19
13-A-C	94	93	93	87	71	66	61	55	52	49	36	34	16
17-A-C	94	93	92	92	73	65	62	54	51	50	36	33	17
9-A-P	94	93	94	92	93	91	92	91	91	89	91	91	73
13-A-P	94	92	92	68	94	92	93	90	92	90	91	91	72
17-A-P	89	88	72	90	41	34	15	5	0	0	0	0	0
9-CS-C	93	92	93	92	93	89	91	90	90	90	91	90	72
13-CS-C	94	93	92	91	92	89	90	89	91	91	92	92	71
17-CS-C	93	92	92	91	93	88	91	89	90	89	91	89	69
9-CS-P	92	93	94	92	92	92	90	90	92	92	92	90	70
13-CS-P	92	92	92	91	93	91	92	91	91	91	91	88	72
17-CS-P	93	93	93		93	91	89	88	90	90	90	91	68

LSD for germination *in-vitro* between any treatments and time periods (.01 level) = 3.45
LSD for emergence in sand between any treatments and time periods (.01 level) = 4.64
LSD for field emergence between treatments after 12-months storage (.01 level) = 5.32

1/ Nine, 13 and 17 = percent initial moisture content; A = ambient conditions at Mayaguez; CS = cold storage conditions at Lajas; C = cloth bag; and P = sealed plastic bag.
2/ Percent seed germination *in-vitro*, emergence in sand, and field emergence based on 3 replications of 100 seed per treatment and time period.
3/ Field emergence was recorded only after 12-months storage.

2. Weed Science

Weeds are a major problem in the production of most field crops in the tropics. Research conducted under this grant has demonstrated that without successful weed control, soybean production in the tropics is not feasible. Program emphasis in the area of weed science has been placed on the identification and study of competitive characteristics of weed species commonly associated with soybeans in the tropics, and the development and application of feasible weed control methods.

Research on the competitive ability of weed populations against soybean production has been in progress for the past two years at the University of Puerto Rico. Variations in the degree to which soybean yields are reduced by weeds have been observed and recorded. This variation appears to depend on weed species involved, amount of weeds (population), cultural practices being used, and climatic conditions. Work in this area will be continued and expanded in order to determine which weed species present the greatest danger to soybean production in the tropics, and to relate their growth characteristics with their competitive ability against soybean. In addition, the behavior of weeds toward variations in cultural practices will be studied.

A number of herbicides have been studied over the past two years for their selectivity to soybean and their ability to control tropical weed pests of soybean. The behavior of these herbicides has been observed over a variety of soil types and weed populations. Although no products are completely effective for all environmental conditions and weed species. Future work with herbicides will be focused on determining and applying the proper methodology for using herbicides in the overall weed management program.

The use of various agronomic practices in controlling weed pests, as well as, mechanical and manual methods of weed control will be studied. Of primary concern, will be their methodology and application within the overall soybean production program in the tropics.

Research conducted during the report period can be divided into two major areas: (a) Chemical control and (b) weed competitions studies

a. Chemical control

Herbicide trials were established at the Lajas and Isabela substations. The primary objectives of these trials were: (1) to further evaluate compounds for their selectivity to soybean and efficiency in controlling selected weed species under various tropical conditions; (2) to obtain information which will provide solutions to specific weed control problems; and (3) to evaluate the selectivity and percentage weed control on newly developed herbicides.

Herbicides evaluations were conducted as follows:

Soybeans of the cultivar "Improved Pelican" were planted at a density of 330,000 plants per hectare, with 60 cm between rows. Seed were inoculated with *Rhizobium japonicum* in the planter box. Triple superposphate was applied at the rate of 100 kg/ha. Herbicides were applied with an A-Z CO_2

powered sprayer at a pressure of 30 p.s.i. Spray volume was equivalent to 200 liters per hectare. Treatments were arranged in a randomized complete block design with an individual plot size of 3 x 10 meters.

Preplant incorporated (PPI) compounds were mixed with the soil prior to planting using a Troy-Built rototiller. Sprinkler irrigation was applied immediately after application of the preemergence (PEM) treatments and afterwards as needed. Insects were controlled chemically. Insecticide, rate and time of application varied with insects species and intensity.

The soil in which the trials were conducted has the following characteristics:

Isabela = ph 7.7, organic matter 3.2%, clay 51.8%, silt 24.8% and sand 23.4%.

Lajas = ph 5.9, organic matter 4.2%, clay 65.1%, silt 23.8% and sand 11.1%.

The predominant weed speciesat Isabela were: *Euphorbia heterophylla*; *Ipomoea tiliacea* and *Oxalis curviculata*. Populations of *Echinochloa colonum*, *Digitaria sanguinalis* and *Eleusine indica* were also present in small amounts.

The predominant weeds species at Lajas were: *Sorghum halepense* (johnson grass) and *Cyperus rotundus* (purple nutsedge). Small populations of *Ipomoea tiliacea*, *Eshinochloa colonum*, *Digitaria sanguinalis* and *Eleusine indica* were also present.

Herbicide trials were conducted at both Lajas and Isabela. Additional trials were conducted at Lajas for the specific control of johnson grass. The following data was collected from herbicide trials: (1) a visual (subjective) rating of herbicide toxicity to soybean was conducted. A scale of 0-10 was used, where 0=(no damage) and 10=(complete kill); (2) visual ratings for percentage control were made for each treatment. Ratings were expressed as a percentage of the unweeded plots; (3) weed samples were collected by throwing a wooden frame (50 x 25 cm) into each plot twice. Weeds within the frame were collected in paper bags and taken to the laboratory for identification, counting and weighing.

Results of the herbicide trials were as follows:

Isabela

1. General herbicide evaluation

Previous trials have been conducted at Isabela in 1976 and 1977. In these trials, consistantly good weed control has been observed with metribuzin (0.75) (Note: all numbers following chemical names represent the rate applied in kilograms of active ingredient per hectare), RP 20630 (1.0), RP 20810 (1.0) and combinations of metribuzin (0.5) and alachlor (1.0). Toxicity of metribuzin, RP 20630 and RP 20810 to soybean has varied from year to year, and appears to be highest when high rainfall occurs shortly after application. The highest degree of toxicity has been observed on RP 20630 followed by RP 20810, with metribuzin showing the lowest degree of toxicity. All three of these

products gave good control of *Ipomoea* sp., with metribuzin giving the highest degree of control. Other promising treatments included linuron (2.0) and linuron plus metribuzin (1.0 + 0.5).

In the 1978 trial, metribuzin alone (0.75) and in combination with several other products gave good results (tables 9 & 10). Good control for up to 30 days was obtained by oryzalin + metribuzin (1.0 + 0.5), vernolate + trifluralin (3.0 + 1.0), vernolate (4.0); alachlor + metribuzin (1.0 + 0.5) and metribuzin (0.75). Best control was observed on plots treated with oryzalin + metribuzin (1.0 + 0.5) and alachlor + metribuzin (1.0 + 0.5), with 73 and 67% control, respectively, at 6 weeks after treatment.

In general, treatments with lower weed counts and weed weights provided the highest yields. One exception was alachlor (2.0) which had high weed counts and weights. The high counts and weights were due primarily to *Oxalis corniculata* which does not compete vigorously against soybean.

Highest yields were obtained from plots treated with metribuzin (0.75) and oryzalin + metribuzin (1.0 + 0.5). The average number of weeds per meter of row for these two treatments were 7.70 and 7.75, respectively. Alachlor + metribuzin (1.0 + 0.5) gave a similar degree of control with 7.8 weeds per meter of row; however, yields for this treatment were much lower. The average number of pods per plant for alachlor + metribuzin (1.0 + 0.5) was 81.9. The average number of pods for metribuzin (0.75) and oryzalin + metribuzin (1.0 + 0.5) were 120.0 and 129.6, respectively. The main difference observed between these treatments was a high count and weight for *Ipomoea* sp. in the alachlor + metribuzin treatment.

Lajas

2. General herbicide evaluation

Trials were conducted in the same field which has been used for the previous two years. Predominant weed species in the experimental area include: *Sorghum halepense*, *Ipomoea liliaceae*, *Echinochloa colonum*, and *Commelina difusa*. The soil at this particular area is heavy (65% clay), and has poor internal and external drainage. When heavy rainfall occurs soon after planting, toxicity has been observed on several treatments, which are very selective for soybean under other environmental conditions. The combination of poor soil drainage and heavy rainfall soon after planting usually results in increased phytotoxicity of several herbicides to soybean.

In previous trials at Lajas, most of the compounds in the dinitroanilene group (used at rates from 1.5 to 2.0 kg a.i./H) have provided relatively good control of grasses. However,

when used alone, broadleaf weeds, especially *Ipomoea* sp., rapidly invade the plots. Metribuzin, at the rates of 0.5 and 0.75 Kg a.i./H, controls broadleaf weeds and a few annual grasses. The best total control at Lajas has been observed when compounds in the dinitroanilene group are used in combination with metribuzin; however, the problem of phytotoxicity is often observed with these combinations. Therefore, we need to develop alternative methods of control. Additional research needs to be conducted in the following areas: (1) development and testing of more selective preemergence applied compounds; (2) evaluation of preemergence applied compounds followed by postemergence compounds; and (4) the use of direct applied postemergence compounds.

In order to screen new treatments and compare them with the best treatments observed in previous trials, a trial including twenty treatments was established on June 27, 1978. Data on degree of phytotoxicity and percent control of total weed species is presented in table 11. The trial was not taken to yield because many plots became heavily infested with *Ipomaea* sp. and Johnson grass after the fifth week.

A low degree of phytotoxicity was observed for all treatments, even those which had pronounced phytotoxicity to soybean in previous trials at Lajas. This is probably due to the low amount of rainfall which occurred shortly after planting. Low rainfall permitted the application of desirable amounts of water.

The best total control at three weeks after planting was observed in plots treated with: oryzalin + metribuzin (1.0 + 0.5); metribuzin (0.75); metolachlor + metribuzin (1.0 + 0.5), alachlor + metribuzin (1.0 + 0.5); vernam + trifluralin + metribuzin (3.0 + 1.0 + 0.5) and linuron + metribuzin (1.0 + 0.5). The previously mentioned treatments also showed good control at five weeks after planting.

Good control of broadleaf weeds, especially *Ipomaea* sp., was observed at three and five weeks after planting in plots treated with carboflurofen. These results were similar to those reported for Isabela.

Table 9. Soybean Herbicide Evaluation, Isabela 1978. Toxicity, degree of control and yield.

Treatment	Rate kg a.i/ha	Time of Application	Toxicity Score A	Toxicity Score B	Toxicity Score C 3/	Percent control A	Percent control B	Percent control C	Yield kg/ha
1. Trifluralin	1.5	PPI 1/	1.3	1.3	1.3	75	57	43	2.117
2. Trifluralin / Metribuzin	1.0 / 0.5	PPI	1.0	1.7	1.0	70	57	43	2.145
3. Vernolate	4.0	PPI	3.0	2.0	0.7	90	73	50	1.908
4. Vernolate / Trifluralin	3.0 / 1.0		2.3	1.7	1.0	93	77	53	1.938
5. Vernolate / Trifluralin / Metribuzin	3.0 / 1.0 / 0.5	PPI	1.6	2.3	1.3	83	70	53	1.966
6. Alachlor	2.0	PEM	1.0	1.3	0.7	67	57	47	1.983
7. Oryzalin	1.5	PEM	0.7	1.7	1.7	63	57	43	1.694
8. Metribuzin	0.75	PEM	0.7	0.3	0.0	75	70	50	2.317
9. Oxadiazon	1.0	PEM	1.3	1.7	1.0	78	67	57	1.873
10. Linuron	1.5	PEM	1.0	2.3	1.7	43	43	33	1.639
11. Alachlor / Metribuzin	1.0 / 0.5	PEM	2.0	0.7	0.0	83	73	67	1.836
12. Oryzalin / Metribuzin	1.0 / 0.5	PEM	2.0	3.3	2.0	85	80	73	2.236
13. Linuron / Metribuzin	1.0 / 0.5	PEM	0.3	0.7	0.3	73	63	50	1.971
14. Metolachlor	1.0	PEM	1.0	0.3	1.0	50	50	37	1.521
15. Metolachlor / Metribuzin	1.0 / 0.5	PEM	0.7	0.0	0.0	77	53	43	1.933
16. Caroflerofen	0.75	POST 4/	---	0.3	0.3	0	70	50	2.026
17. Basagran	1.5	POST	---	0.0	0.0	0	27	17	1.652
18. Handweeded			---	---	0.0	100	100	100	1.967
19. Cultivation at 24 days			---	---	0.0	0	63	63	2.003
20. Unweeding			---	---	0.0	0	0	0	1.268

1/ PPI = Preplanted incorporated; PEM = Preemergence; POST = Postemergence
2/ 0 = no injury = 10 = complete kill
3/ A = 2 weeks; B = 4 weeks; C = 6 weeks after planting.
4/ POST = Postemergence

Table 10. Soybean Herbicides Evaluation, Isabela 1978. Weed number and weed weight by species in .375 m^2 at 4 weeks after planting.

Treatment	Weed Number						Weed Weight (grams)					
	A[1/]	B	C	D	E	Total	A	B	C	D	E	Total
1. Trifluralin	1.0	49.7	6.0	---	2.7	59.4	.2	90.0	11.5	---	3.5	105.2
2. Trifluralin / Metribuzin	1.3	46.0	19.0	16.0	5.3	87.6	3.6	77.5	26.2	4.0	6.9	118.2
3. Vernolate	7.0	31.3	12.7	10.7	5.3	67.0	4.1	37.2	15.6	3.1	5.9	65.9
4. Vernolate / Trifluralin	---	31.0	6.3	7.7	4.7	49.7	---	29.1	9.4	4.3	7.0	49.8
5. Vernolate / Trifluralin / Metribuzin	---	58.3	3.3	9.0	1.7	72.3	---	69.2	4.2	3.1	2.1	78.6
6. Alachlor	4.0	71.0	16.0	134.7	3.0	228.7	3.0	69.2	40.8	33.2	2.5	148.7
7. Oryzalin	2.7	50.0	0.7	27.3	5.3	86.0	1.7	87.2	2.7	8.7	3.6	103.9
8. Metribuzin	10.0	68.3	10.0	52.7	4.7	145.7	10.0	49.6	6.0	15.5	2.4	83.5
9. Oxadiazon	6.3	28.3	26.3	42.0	7.0	109.9	15.6	29.6	84.0	7.5	9.5	146.2
10. Linuron	13.3	48.0	36.3	52.0	4.0	123.9	5.9	37.3	91.1	16.6	5.1	156.0
11. Alachlor / Metribuzin	3.0	13.3	16.0	11.3	3.3	46.9	10.7	26.7	25.8	34.8	2.7	100.7
12. Oryzalin / Metribuzin	2.3	30.3	1.3	43.7	3.7	81.3	1.2	36.1	1.8	11.2	7.2	57.5
13. Linuron / Metribuzin	19.3	50.7	6.7	47.0	6.3	130.0	6.9	42.3	5.4	23.8	7.2	85.6
14. Metolachlor	2.7	61.7	24.7	20.7	5.7	115.5	2.8	103.6	49.4	5.7	2.7	164.2
15. Metolachlor / Metribuzin	1.0	82.0	9.3	22.7	3.3	118.3	0.3	88.3	10.3	7.8	2.6	109.3
16. Caroflerofen	11.3	30.0	17.0	9.7	4.7	72.7	50.6	36.0	17.5	3.9	11.3	119.3
17. Basagran	10.0	59.0	27.0	123.7	5.3	225.0	28.2	80.1	54.1	44.5	9.5	216.4
18. Handweeded	---	---	---	---	---	---	---	---	---	---	---	---
19. Cultivation at 24 days	24.7	8.7	3.3	66.0	3.0	105.7	42.0	14.9	13.5	16.4	6.6	93.4
20. Unweeding	20.7	37.3	30.3	29.3	14.3	131.9	37.0	62.2	60.7	8.1	25.7	193.7

1/ A = Annual grosses *Echinochloa colonum* and *Eleusine indica*
B = *Euphorbia heterophylla*
C = *Ipomoea tiliacea*
D = *Oxalis curviculata*
E = Other broad leafed species.

Table 11. Soybean herbicide evaluation, Lajas, 1978. Crop injury and percent weed control at 3 and 5 weeks after planting.

Treatment	Rate kg a.i/ha	Time of application	Percent control: Crop Injury 1/ July 15 2/	Crop Injury 1/ Aug. 1	Total Control July 15	Total Control Aug. 1	Broad leaf Aug. 1	Grasses Aug. 1
1. Trifluralin	1.5	PPI	0	0	25	27	13	37
2. Trifluralin / Metribuzin	1.0 / 0.5	PPI	0.7	1.0	45	55	43	67
3. Vernolate	4.0	PPI	0	0	50	42	30	53
4. Vernolate / Metribuzin	3.0 / 1.0	PPI	0	0.3	50	52	37	67
5. Vernolate / Trifluralin / Metribuzin	3.0 / 1.0 / 0.5	PPI	1.3	1.7	83	65	67	63
6. Alachlor / Carboflurofen	2.0 / 0.75	PEM/POST	0.3	0.7	43	70	60	80
7. Oryzalin / Carboflurofen	1.5 / 0.75	PEM/POST	1.0	0.7	10	70	63	77
8. Metribuzin	0.75	PEM	0·7	1.3	87	74	77	70
9. Oxadiazon	1.0	PEM	0	0.3	47	18	13	23
10. Linuron / Carboflurofen	1.5 / 0.75	PEM/POST	0	0	33	61	50	73
11. Alachlor / Metribuzin	1.0 / 0.5	PEM	0.7	1.0	83	72	73	70
12. Oryzalin / Metribuzin	1.0 / 0.5	PEM	1.0	0.7	90	79	80	77
13. Linuron / Metribuzin	1.0 / 0.5	PEM	0.3	1.0	80	67	67	67
14. Metolachlor / Carboflurofen	1.5 / 0.75	PEM/POST	0	0.7	40	65	60	70
15. Metolachlor / Metribuzin	1.0 / 0.5	PEM	0	0	83	72	77	67
16. Oxifluorfen	0.5	PEM	0	0.7	40	32	20	43
17. Carboflurofen	0.75	POST	0	1.0	10	56	57	55
18. Lasso / Oxifluorfen	1.5 / 0.5	PEM/POST	0	0.7	57	55	37	73
19. Trifluralin / Carbofluorfen	--- / ---	PEM/POST	0	0	53	74	70	77
20. Handweeded	---	---	0	0	100	100	100	100
21. Unweeded	---	---	0	0	0	0	0	0

1/ 0 = No injury - 10 = complete kill
2/ Date observations were recorded - 1978.

3. Control of Johnson grass with Dalapon

Dalapon at the rates of 5, 7.5, 10, 15 and 20 kg a.i/H were evaluated in single and repeated applications at one month intervals. Single applications of 5, 7.5 and 10 kg a.i/H failed to provide effective and lasting control. Fifteen and 20 kg a.i/H provided 70 and 75% control, respectively, for up to three months after application. When plots received two applications of 10 kg a.i./H, they had a higher percentage control than those treated with single applications of 20 kg a.i./H. Best control was obtained with three applications of 7.5 kg a.i./H. Plants in all plots were cut on November 10, 1978 and the number of Johnson grass plants which recovered was recorded on November 20, 1978. Less recovery was recorded in plots receiving three applications of either 5, or 7.5 kg a.i./H. Plots treated once with 15 kg a.i./H also showed a low level of Johnson grass recovery.

4. Evaluation of non-selective herbicides for Johnson grass control in soybean

An area infested with about three Johnson grass plants per m^2 was used for this trial. On July 24, bromacil (6.0, 12.0 and 18.) and velpar (1.0, 2.0 and 4.0) were applied before emergence of the weeds. On September 24, velpar (1.0, 2.0 and 4.), glyphosate (1.0, 2.0 and 3.0), Dalapon (5.0, 7.5 and 10) and asulox (2.0, 3.0 and 4.0) were applied over Johnson grass plants about 50 cms. tall.

On October 3, seventy days after the application of preemergence treatments, there were about 0.8 Johnson grass plants per m^2 in plots receiving bromacil (6.0) and none in plots treated with higher rates. Plots treated with all rates of velpar had an average of 0.2 plants per m^2. Control (nontreated) plots had an average of 2.2 plants per m^2.

On October 3, ten days after the application of the postemergence treatments, there was a complete kill of Johnson grass in all plots treated with glyphosate. Severe symptoms of toxicity in Johnson grass was observed in plots treated with asulox followed by dalapon, with velpar showing the least degree of toxicity.

One row of soybean was planted on October 3 in plots treated with preemergence treatments and five rows (on 60 cm centers) were planted in plots treated with glyphosate. Soybean seeds germinated, but by October 18, 53% of the plants had been killed or exhibited severe toxicity symptoms in plots treated with bromacil (6.0), and 100% of the plants were killed at higher rates. Control of Johnson grass was 67% in plots treated with bromacil (6.0) and 100% for the higher rates.

In plots treated with velpar (1.0), soybean showed only slight injury symptoms; however, toxicity from velpar increased with an increase in rate. Johnson grass control was over 70% for all rates of velpar applied as a preemergence treatment.

No injury was observed on soybean in plots treated with glyphosate. Plots treated with glyphosate became heavily infested with annual weeds shortly after planting soybeans; however, Johnson grass was completely controlled. This indicates that measures for controlling annual weeds are necessary when planting soybeans after destruction of Johnson grass with glyphosate.

Asulox, dalapon and velpar gave 89, 82 and 55% control of Johnson grass, respectively, when applied as postemergence treatments.

On November 5, Johnson grass was cut from plots which received velpar, asulox and dalapon as a postemergence treatment applied directly to the weeds. One row of soybean was planted in each plot. An additional row of soybean was planted in the plots treated with preemergence treatments. On November 20, 90 and 60 days after the application of preemergence and postemergence treatments, respectively, there was no injury symptoms on soybean in any of the postemergence treatments. Only slight symptoms were observed in plots treated with velpar (1.0, 2.0 and 4.0) as a preemergence. Severe toxicity on soybean was observed in plots treated with bromacil (12.0 and 18.0), and moderate toxicity was observed with bromacil (6.0).

Johnson grass control was 42% in plots treated with bromacil (6.0) and 100% in plots treated at higher rates. Plots treated with velpar had an average control of 75%.

The average number of Johnson grass plants per plot which recovered after treatment with all rates of glyphosate, asulox, dalapon and velpar was: 1.9; 22.0; 23.0 and 42.0, respectively.

b. Weed competition studies

1. Effect of time and frequency of weeding on yield of 3 soybean cultivars

Previous trials conducted under this grant have indicated that under favorable conditions for germination and growth, the period between the 3rd and 5th week of soybean growth is when weeds (which start growth simultaneously with the crop) have their maximum adverse effect on yield.

An experiment was established in order to observe the effect of frequency and timing of weeding on yield of the cultivars Improved Pelican, Jupiter and Williams. The trial was planted in Isabela on June 6th using an split-plot design with 4 replications. The main plots were cultivars and sub-plots were weed control treatments.

Weed samples in three 25 x 50 cm frames were taken weekly from the plots prior to being weeded on that particular date. Soybean plant height was taken weekly from the second through the eight week after emergence. Weedings and sampling started on June 15th or one week after soybean emergence.

Weed population consisted mainly of *Euphorbia heterophylla*, *Oxalis martiana*, and *Ipomoea tiliacea*. The changes in proportion of the different weed species expressed as percent of fresh weight during the first 7 weeks are presented in table 12.

It can be observed from this table that at the beginning *O. martiana* was the most abundant weed but was dominated from the second week on by *E. heterophylla* which contributed with the largest amount of fresh weight. The proportion of grasses started to increase the 3rd week and this increase was more pronounced in the plots of the cultivar Williams. In Williams, the largest fresh weight of weeds was also recorded.

As seen in figure 1, growth of weeds was more rapid between the fourth and fifth week after emergence of soybeans. Weeds increased in number from 242 plants/m^2 the first week after emergence to 411 the 4th week. After this time weed number was relatively constant so that the increase in fresh weight during the 4th week was due mainly to increase of biomass, hence they were using large amounts of water and minerals. Growth of soybean cultivars measured as plant height increased for the cultivar Williams up to the end of the 6th week after emergence. The other two cultivars still increased in size after the 8th week. In general, they grew over a more extended period of time than the predominant weeds.

The effect of weeding treatments on weed components shows that with the same number of plants per plot the number of pods per plant decreases in unweeded plots. The plots more frequently weeded had the largest number of pods per plant.

There was not very much difference in the number of seeds per pod among treatments. Effect of the weeding treatments on one hundred seed weight was evident only in the cultivar Jupiter where the unweeded control had 16.1 gms and plots weeded every week had 19.6 gms/100 seeds.

The yields obtained from this trial are presented in table 13. Comparing the average for the three cultivars it can be observed that two weedings at 16 and 30 days after planting provided yields very similar to those weeded every week until the 37th day. Looking at the yields of the individual cultivars it can be observed that Improved Pelican provided higher yields when weeding was performed at 16 and 30 days. A single weeding at 30 days provides better yields than when performed at either 16 or 23 days after planting. For the cultivar Jupiter a single weeding at 30 days provided similar yields to those of plots weeded at 16 and again at 30 days, and to plots weeded every week up to the 37th day. This cultivar seems to either restrict weed growth after the 30th day more efficiently than Improved Pelican and Williams, or to tolerate more competition during the 30 initial days.

The cultivar Williams provided higher yields when weeded every week until the 37th day and with 2 weedings at 9

and 30 days. This fact indicates that cultivars that do not cover the ground completely need more protection against weed competition. Furthermore since this cultivar has a shorter growing period, critical weed competition may develop earlier so that weeding programs have to start earlier. This may also be true for the other cultivars when planted during the periods of short day length in Puerto Rico.

The treatment of alachlor plus metribuzin (1.0 + 0.5 kg a.i./Ha) behaved similarly to single early weedings, especially for the late cultivar. It appears that this treatment needs to be complemented with hand weeding or cultivation performed at around 30 days after planting in order to minimize yield reduction due to weed competition.

The data obtained from this experiment will be analized statically and will be incorporated into a publication together with the previous data on weed competition with soybeans.

2. Effect of plant and row spacing of 3 soybean cultivars on growth of weeds.

This trial is being harvest at the present time. The information obtained will be presented in next year's report.

Table 12. Proportion of weed species. Weed competition study - Isabela 1979.

Weed species	Weeks after soybean emergence						
	1	2	3	4	5	6	7
	% Fresh weight 1/						
E. heterophylla	33	46	49	67	68	74	72
O. martiana	52	30	21	9	3	2	2
I. tiliacea	7	13	9	7	8	8	7
other dycots.	3	4	9	7	5	5	6
Grasses 2/	5	7	12	10	16	11	13

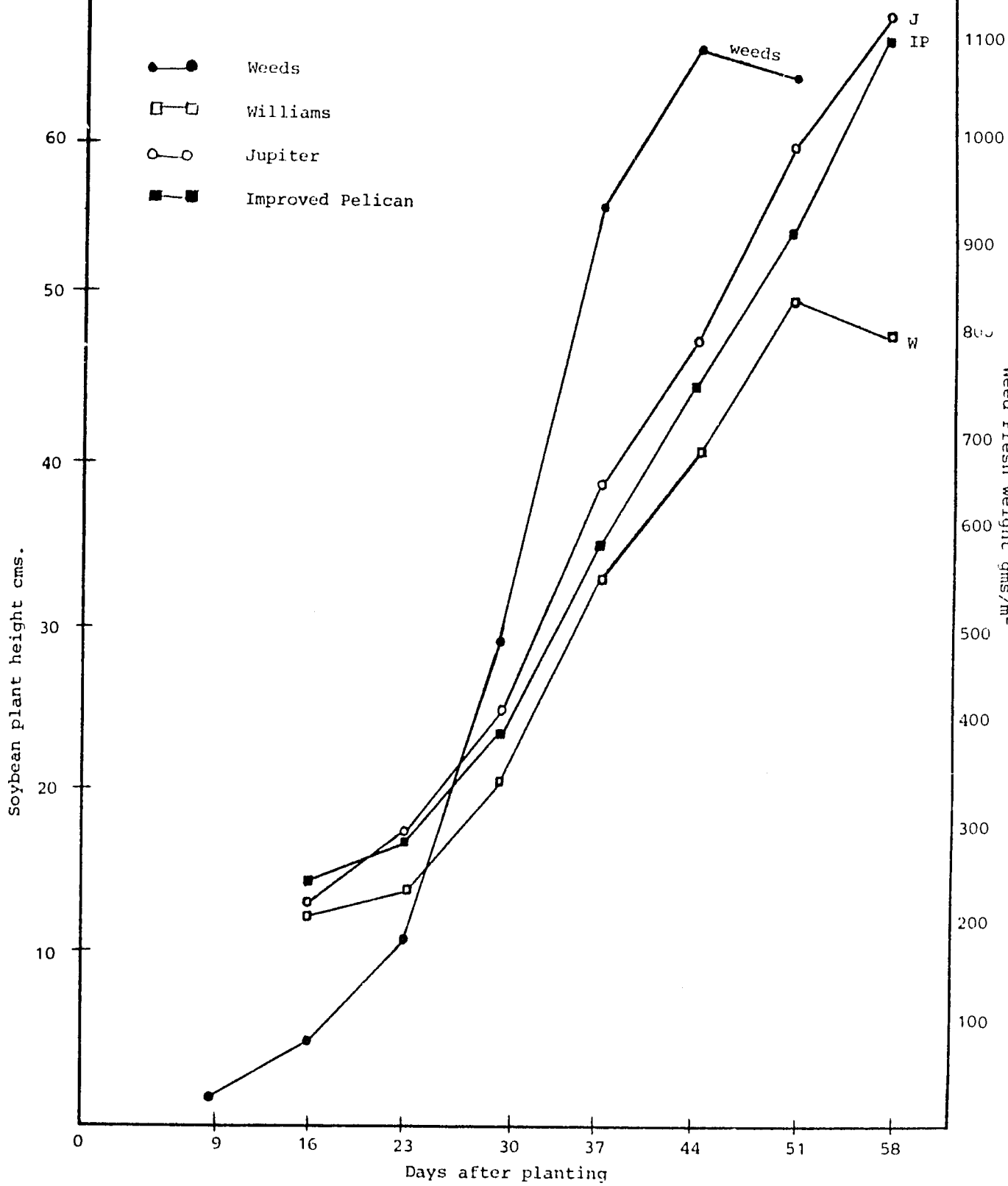
1/ Average for the 3 cultivars.

2/ *Digitaria sanguinalis*, *Echinochloa colonum*, *Eleusine indica*, *Cenchrus echinatus*.

Table 13. Yield of 3 soybean cultivars under different weeding schedules. Weed competition study - Isabela 1978.

Weeding time in days from planting	Improved Pelican	Jupiter	Williams	Mean
	Yield kgs/ha			
16 days	1556	1743	1244	1514
23 days	1411	1674	1255	1447
30 days	1910	2043	1394	1782
9-23	1700	1737	1801	1746
16-30	2274	2004	1488	1922
from 9 to 37	2121	2161	1893	2058
Chemical	1422	1216	1635	1424
Unweeded	720	931	825	825

Figure 1. Growth of 3 soybean cultivars and of associated weeds - Isabela, Puerto Rico - 1978.



3. Nematology

a. Survey of nematode species in soybean plots at Isabela.

Seventy one soil samples were collected from soybean plots at Isabela. The nematode species isolated from 250cc of soil were: *Rotylenchulus reniformis*, *Helicotylenchus* sp., *Tylenchorhynchus crassicaudatus*, *Tylenchus* sp., *Aphelenchus* sp. and *Aphelenchoides* sp. *Rotylenchus reniformis* was found in 95% of the samples and had the highest population levels. Soil factors such as concentration of phosphorus, potassium, calcium, magnesium, % organic matter, pH, and nitrogen content and the cation exchange capacity were determined. All of these factors will be correlated with nematode population levels. Further information on this survey will be presented in next year's annual report.

b. Screening for nematode resistance and the effect of chemical control.

A field experiment was established to evaluate the degree of resistance or susceptibility of 20 soybean cultivars to the different nematode species in soybean. The soybean cultivars tested were: Bossier, SJ-1, Davis, Parana, Orba, Santa Rosa, Calland, Bragg, HLS, CH_3 increased, Improved Pelican, ICA Caribe, Hardee, Ponce, Buffalo, Hill, Local (S.L.), Williams, Clark 63, and Jupiter. The effect on nematode control of the nematicide-insecticide Mocap 10G at rate of 18.2 k gms a.i./ha was also studied in this experiment. Another field experiment will be initiated shortly using 13 soybean cultivars. Cultivars such as Hutton, Forrest and Bedford (which are resistant to the soybean cyst nematode) will be included. A treatment of Mocap 10G applied to the soil at planting time will be included to test the effect of the nematicide on the nematode population and on the development of each cultivar.

Other field experiments will be established to test different nematicides applied preplant to the soil at different dosages for the control of the most important nematodes species in the Isabela area.

c. Screening for resistance to root-knot nematode in soybean.

Two populations of the root-knot nematode, (*Meloidogyne* sp.) one from tomato (*Lycopersicum esculentum*) from Isabela and the other one from squash (*Cucurbita pepo*) from Santa Isabel are maintained and increased in the tomato cultivar Rutgers in the greenhouse. The resistance of more than 50 soybean cultivars to these root-knot populations and others will be studied and evaluated under greenhouse conditions.

4. Associated and Cooperative Research

The development of a strong and meaningful linkage between UPR/MC

and UIUC has lead to the initiation of several important associated research projects. Under the companion grants, AID/CM/ta-g-73-50 (UPR/MC) and AID/CM/ta-g-73-49 (UIUC), an interinstitutional, co-operative, coordinated and interdisciplinary research program has been developed. Through cooperation with UPR/MC, UIUC has developed a strong soybean varietal development program for the tropics at Puerto Rico. Through this same cooperation, UPR/MC scientists can work directly with the plant breeder. UPR/MC and UIUC personnel are using the plant breeder and the breeding program as a vehicle to develop better-quality seed and resistance to disease, weeds and insects.

Several research projects have been initiated since 1975 dealing with specific problems affecting the ability of soybean cultivars to adapt to different environmental and cultural conditions. Work is underway in the following areas:

a) Seed quality deterioration experiment to study genetic differences in tropical soybean germplasm for storability under adverse conditions;

b) Testing soybeans for percentage seed transmission of Soybean Mosaic Virus;

c) Studying the inheritance of resistance to Soybean Mosaic Virus;

d) Studying the inheritance of the hard seed coat characteristic in soybean.

e) Studying the inheritance of good seed quality characteristics in tropically adapted soybean cultivars;

f) Intercropping of soybean and sorghum;

g) Effects of weed competition on nodulation of soybean by *Rhizobium japonicum*; and

h) The effect of seedling vigor on soybean nodulation by *Rhizobium japonicum*'

The majority of these studies will be presented in detail in future annual reports or in appropriate annual reports from INTSOY-UIUC. Brief summaries of two projects are presented in Appendix A.

Output II. Education and Training

The primary objective of this output is to build institutional response capability through strengthening of the educational and training capabilities at UPR/MC in the area of tropical crop protection. Graduate studies, short term work-study training programs, and staff participation in on-campus and on-site courses, seminars, workshops and conferences are the primary means of addressing this objective.

1. The Development of the Department of Crop Protection at UPR/MC.

The grant has had a marked effect on the development of the University of Puerto Rico's plant sciences program. In July 1977, the College of Agricultural Sciences established the Department of Crop Protection. This new department integrates the disciplines of plant pathology, nematology, entomology, weed science and pesticide usage into a single program. Integration of teaching, research and extension is also achieved through the development of the new department. The department has a staff of 50 scientists, most of which are the M.S. and PhD level.

The primary objectives of the new department are:

1) To conduct research in the areas of entomology, plant pathology, nematology, weed science, pesticide evaluation and application, residue analysis and environmental protection. All research will be directed towards the development of technology in the area of tropical crop protection and pest management;

2) to train competent professional personnel who can effectively develop and apply technology in the area of tropical crop protection; and

3) effectively disseminate the technology of tropical crop protection for the benefit of agriculture and the community in general.

Grant personnel and activities have had a direct effect upon the development of the Department of Crop Protection at UPR/MC. All grant personnel are faculty members of the Department of Crop Protection and have been active in the development of a new curriculum for both the graduate and undergraduate programs. Dr. Alejandro Ayala is the head of the new department.

The establishment of the new department will strengthen UPR/MC institutional response capabilities in education and training in the area of tropical crop protection.

2. Graduate Studies.

At present, there is a shortage of well trained personnel in the fields of tropical crop protection and production of soybean and other grain legumes. It is a major objective of this grant to provide advanced degree training to qualified persons from tropical

LDCs. Research facilities and support provided by the grant are excellent. A total of 20 courses relevant to the science of crop protection are currently being offered by the Department of Crop Protection. These courses are being taught in Spanish. The opportunity for advanced degree training in the field of tropical crop protection (especially for persons from the LDCs of Latin America) is currently available at UPR/MC.

During the reporting period the following graduate students have received grant support for their thesis research:

a. Mr. Oswaldo Zambrano completed his M.S. degree in crop protection with a specialization in plant pathology. Mr. Zambrano is the first student to receive the M.S. degree from the recently established Department of Crop Protection. The title of Mr. Zambrano's thesis is "Efecto de los hongos sobre la calidad de la semilla de soya en Puerto Rico y algunas medidas para su combate". Mr. Zambrano has returned to Ecuador where he will be conducting research in soybean pathology at the Instituto Nacional de Investigaciones Agropecuarias (INIAP). Mr. Zambrano will make a solid contribution to the development of the national soybean program in Ecuador.

b. Emilio Salaues also completed the M.S. degree in the Department of Agronomy. Mr. Salaues worked under the guidance of Dr. E. H. Paschal (former INTSOY plant breeder). The title of Mr. Salaues' thesis is "Efectos de fotoperiodo en las characteristicas fenologicas de cultivares de soya (*Glycine max*"). Mr. Salaues has returned to his previous position in Bolivia with the Instituto Boliviano de Technologia Agropecuaria (I.B.T.A.). Mr. Salaues will be involved in the soybean breeding program and will make a solid contribution to the national soybean program of Bolivia.

c. Dr. Pornpod Thongmeearkom recently completed the Ph.D. at the Department of Plant Pathology, University of Illinois. A significant portion of Dr. Thongmeearkom's research was conducted at the Isabela substation of the University of Puerto Rico. Dr. Thongmeearkom's research involved various aspects of infection by cowpea mosaic virus of soybeans. The study was divided into three related experiments. These include: transmission of the virus by insect vectors (mainly *Cerotoma* spp.); a yield loss evaluation trial, and a varietal susceptibility trial. Dr. Thongmeearkom has returned to his previous position in Thailand.

d. Mr. Glen Bowers is also a graduate student in the Department of Plant Pathology at UIUC. He has recently completed the M.S. degree in plant pathology and has initiated research for the Ph.D. Mr. Bower's advisor is Dr. Robert M. Goodman. In previous experiments conducted at Puerto Rico, Dr. Goodman identified several soybean lines which may have resistance to

soybean mosaic virus (SMV). Mr. Bowers is studying the inheritance of resistance in some of the promising lines. A significant portion of Mr. Bowers' field research is being conducted at the Isabela substation.

e. Mr. Peerasok Srinives is working toward the Ph.D. in agronomy at the Department of Agronomy, University of Illinois. Mr. Srinives is studying the inheritance of the hard seed coat in soybean. The hard seed coat characteristic may have important implications in relation to soybean seed storage under tropical conditions. A significant portion of Mr. Srinives research is being conducted at the Isabela substation.

f. Mr. Roger Elmore is working toward the Ph.D. in agronomy at the Department of Agronomy, University of Illinois. Mr. Elmore is conducting thesis research in the area of soybean-sorghum intercropping. Mr. Elmore's research is being conducted at the Isabela substation.

g. Mr. Gary Brinkman is working toward the Ph.D. in agronomy at the Department of Agronomy, University of Illinois. A portion of Mr. Brinkman's thesis research is being conducted at the Corozal substation of the University of Puerto Rico. Mr. Brinkman is studying role of calcium in the mechanism of aluminum tolerance in soybeans, the affect of aluminum on soybean root nodulation, and the effect of certain soil treatments on the availability of soil nutrients.

h. Mr. Gonzalo Del Rio has recently initiated study for the M.S. degree in Agronomy. Mr. Del Rio is from Peru and is currently working within the Peruvian national soybean program. Mr. Del Rio's thesis research will be conducted in the area of nitrogen fixation in soybean. He will be studying the effects of moisture, temperature and time on soybean nodulation by *Rhizobium japonicum* in the field. Mr. Del Rio will be working under Dr. Stewart Smith (INTSOY-soil microbiologist).

i. Mr. Americo Celada has initiated study for the M.S. degree in Agronomy. Mr. Celada is from Peru and is currently working within the Peruvian national soybean program. Mr. Celada will be working under Dr. Guillermo Riveros in the area of weed science. His thesis will involve studies on the effect of spacing and plant density on weed growth in soybeans.

j. Mr. Homer Arnulfo Tuesta has also initiated study toward the M.S. degree in agronomy. Mr. Tuesta is from Peru and is currently working within the Peruvian national soybean program. Mr. Tuesta will be conducting thesis research in the area of soybean-corn intercropping. Dr. Tony Sotomayor (plant breeder - U.S.D.A.) has agreed to be Mr. Tuesta's advisor.

k. Mr. Otoniel Mendoza is also from Peru and has recently

initiated study toward the M.S. degree in agronomy. Mr. Mendoza will be working under Dr. Guillermo Riveros in the area of weed control in soybean. His thesis research will involve studies directed toward increasing selectivity of metribuzin to soybean. Mr. Mendoza is also currently working in the Peruvian national soybean program.

The four Peruvian graduate students are at the University of Puerto Rico under scholarships provided by A.I.D. It is anticipated that the experience and knowledge gained by these four men will be of extreme value to the national soybean program in Peru. They shall give leadership to national research programs in the areas of nitrogen fixation, weed control and varietal development of soybean.

The above list of graduate students which have received support from this grant and are currently involved in studies on soybeans, gives a clear indication of the University of Puerto Rico's commitment to the development of a strong training program in tropical soybean production and protection. The University of Puerto Rico has made significant progress toward strengthening it's institutional response capabilities in the area of providing advanced degree training with a specialization in soybeans to qualified persons of the LDCs.

Since the beginning of the grant a total of 22 students have received M.S. degrees with specialization in the area of tropical crop protection. These students represent the following countries: Ecuador, Guatemala, Puerto Rico, Panama, Colombia, Nicaragua, El Salvador and Bolivia. At present, 25 students are enrolled in the graduate program of the Department of Crop Protection at UPR/MC.

Due to the cooperative ties which have been established between UPR/MC and UIUC, an excellent student exchange program has been in progress between the two universities since 1974. Nine graduate students from UIUC have conducted thesis research at UPR/MC. The UPR/MC-UIUC student exchange program has allowed these young scientists to conduct research under tropical conditions. Their international and tropical experience will aid in broadening and deepening the tropical soybean knowledge base.

Five graduate students from UPR/MC have been accepted into graduate programs at UIUC. Four of them are working towards the Ph.D. and one toward the M.S. degree.

Dr. Jaime Jordon recently completed the Ph.D. in the Department of Agronomy at UIUC. He has returned to Puerto Rico and has initiated research in the area of weed control and will also be teaching and advising graduate students.

Dr. Nelia Acosta recently completed the Ph.D. in the Department of Plant Pathology at UIUC. She has returned to Puerto Rico and is initiating research in the field of tropical nematology and is also teaching at the graduate level. Dr. Acosta is giving leadership to the INTSOY-UPR program in soybean nematology in the tropics.

Mr. Arcangel Rodriguez recently completed the M.S. degree in the Department of Plant Pathology at UIUC. He has returned to Puerto Rico and is currently in charge of the plant disease diagnosis clinic at the Rio Piedras substation.

Dr. Julia Hepperly recently completed her Ph.D. in plant pathology and has resumed her teaching and research responsibilities at the Mayaguez Campus.

3. Work-Study Training Program

In recent years, a number of requests have been made for short term nondegree training programs in the area of tropical crop protection and production of soybean. In this type of program, interested and qualified persons will join the INTSOY-UPR staff for on-the-job training in a variety of areas in crop protection. This type of nondegree training eliminates problems of academic prerequisites and language problems in relation to Spanish. At present, trainees from any Spanish speaking country can come directly to Puerto Rico with no language problems. During this reporting period Mr. Cesar Valles Panduro conducted a 4-month work-study program in the area of soybean pathology. The objectives of Mr. Valles' work-study program were: 1) on-the-job training to become thoroughly familiar with the identification, prevention, and modern control methods for soybean diseases; 2) travel and work with plant pathologists and soybean disease specialists to learn research techniques that can be applied in Peru; 3) review research data; and 4) visit various soybean fields to study disease and management problems. After completing a successful program at the University of Puerto Rico, Mr. Valles went directly to the University of Illinois where he attended and completed the INTSOY soybean production short course. Mr. Valles has returned to Peru and resumed his position as soybean pathologist at the experiment station "El Porvenir" at Tarapoto. It is anticipated that the training received by Mr. Valles will be beneficial in strengthening the national soybean program in Peru.

Future work-study programs will be made available to qualified persons from tropical LDCs.

4. Participation in international training activities.

The strengthening of the University of Puerto Rico's institutional response capabilities in the area of tropical crop protection and production of soybean has been demonstrated. Program personnel are available to attend and participate in international training activities such as workshops and short courses. To the fullest extent possible, funding will be used to cover travel and per diem costs for program personnel participating in training activities. The University of Puerto Rico is ready and willing to respond to requests for aid in supplying expertise for training in on-site short courses and other training activities. During the reporting period, only one request for aid in international training activities was received. The University of Puerto Rico did respond to this request.

An international training course on seed technology was held in San Jose, Costa Rica on August 7 through 18, 1978. The course was a cooperative effort between A.I.D., El Centro Para Investigaciones en Granos y Semillas de la Universidad de Costa Rica, and the seed technology laboratory of Mississippi State University. The course was attended by participants from Central America, Panama and the Carribean. Sponsoring organizations did not have developed expertise in seed pathology; therefore, Dr. M. A. Ellis was requested to give two lectures on seed pathology at the course. The following lectures were presented at the course "Actividad microbiana y calidad de semillas" and "Control de patógenos acarreados por semillas".

In order to more fully utilize the developed competency of the University of Puerto Rico's soybean program, grant program personnel need to be involved in more international training activities. It is hoped that A.I.D. and international organizations and institutions will recognize and utilize the training capabilities of the University of Puerto Rico.

Output III. Advisory Capacity

As was mentioned in previous section of this report, UPR/MC has developed and is continuing to develop a research and advisory team in the area of tropical soybean protection and production. UPR/MC has committed itself to the development of an expert response capability in the area of weed, disease and insect control of soybeans and other food legumes for the LDCs of the tropics. This grant has developed and is maintaining competence among it's core staff. Grant personnel are prepared to respond to requests from AID, other donor, and tropical LDCs for expert advise or assistance in the problem area. The function of advisors may include: problem identification and analysis, project design, project operations, education and training, research and evaluation.

The fact that both Spanish and English languages are used by the faculty members and technical personnel especially qualify this university for work with LDCs of Latin America. UPR/MC is in a unique position to provide advise and consultation of value for these areas.

UPR/MC grant personnel are directly linked with the grant personnel of UIUC. Through the combined grant personnel of UIUC and UPR/MC, INTSOY provides an advisory team in the area of tropical soybean protection that can respond to requests for aid in seed production, disease control (fungal, bacterial and virus), insect control, nematode control and weed control of soybean in the tropics.

During the reporting period, requests for aid from Panama and Costa Rica were responded to by UPR/MC grant personnel. The response to the request from Costa Rica has been discussed under "participation in international training activities" (Output II).

A request for technical aid from the Faculty of Agronomy, University of Panama was responded to during the reporting period. Dr. Guillermo Riveros spent ten days in Panama giving consultation and recommendations on weed control in soybean and research methods in soybean weed control.

Dr. Pedro Melendez spent ten days in Panama giving lectures and consultation in soybean disease diagnosis, disease control, and research methods in plant pathology. Dr. Melendez conducted a survey of existing soybean diseases in Panama.

Dr. Michael A. Ellis also spent ten days in Panama giving consultation in soybean seed production and seed pathological problems in the tropics.

Written reports were left by each staff member, prior to leaving Panama.

It is anticipated that UPR/MC requests for advise and consultation in the area of tropical pest control and management of soybean and other grain legumes will increase as the tropical production of soybean increases.

Output IV. Linkages

The primary objective of this output goal is to develop formal research and informational linkages with national and international organizations and institutions. Through the development of these linkages UPR/MC and UIUC can provide leadership for the establishment of an international network of organizations and individuals which are linked in such a utilization of program outputs, and continued development of future soybean production and utilization programs for the tropics and subtropics.

Since the beginning of the grant, linkages have been developed with the following institutions.

(a) International Crops Research Institute for the Semi-Arid Tropics, Hyberadad, India.

(b) Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.

(c) Instituto Colombiano Agropecuario (ICA), Colombia.

(d) Instituto Interamericano Ciencias Agricolas (IICA), El Salvador, San Salvador.

(e) Instituto Nacional de Investigaciones Agropecuarias (INIAP), Quito, Ecuador.

(f) Universidad de Panama, Panama.

(g) International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

(h) Centro Internacional de la Papa (CIP), Lima, Peru.

(i) Ministerio de Alimentacion, Lima, Peru.

(j) Asian Vegetable Research and Development Center (AVRDC), Taiwan.

(k) Fundacao Instituto Agronomico do Parana (IAPAR), Londrina, Brasil.

(l) Canada Agriculture Research Station, Winnipeg, Manitoba.

At the national level, linkages have been developed with the Mayaguez Institute of Tropical Agriculture (MITA), the United States Department of Agriculture and Agricultural Research Service, Iowa State University, North Carolina State University, Mississippi State University, Oregon State University and the University of Hawaii.

Output V. Information Capacity

Through the development of grant supported research activities, a significant amount of new information relative to soybean breeding, seed production and crop protection for the tropics has been developed. This information is intended to have practical application for the LDCs of the tropics. This information is currently being published in scientific journals and will be distributed among tropical LDCs and international centers that have interest in the production of soybeans and other food legumes for human consumption.

Human resources are a major portion of UPP/MC information capacity. Highly qualified staff personnel are aware of research being conducted within their respective fields. Through informational linkages and information generated through program research, grant personnel are an extremely valuable source of information which can be supplied on relatively short notice. Through correspondence, travel and publication, the bank of information and data which is available is being disseminated to tropical LDCs and other interested organizations and individuals.

The library at UPR/MC contains all major journals and other publications pertaining to tropical agriculture and agriculture in general. Reference material on any subject is readily available to staff personnel and graduate students. In addition, UPR/MC is linked with national and international organizations which provide information retrieval services. Special reference is made to the Soybean Insect Research Information Center (SIRIC) of UIUC and the information retrieval service of the Centro Internacional de Agricultura Tropical (CIAT) on *Phaseolus vulgaris*.

E. Impact of Grant - Supported Activity in Achieving Grant Purpose

There is no question that grant funding has had a positive effect in developing UPR/MC institutional response capability in the tropical crop protection and production of soybean and other food legumes. Grant supported activities are an integral part of the Department of Crop Protection. The Department has demonstrated it's keen interest in contributing to the grant program.

The grant has had a profound effect on the teaching program within the college of agricultural sciences and the Department of Crop Protection. Staff personnel have been active in the development of the curriculum for the new department and three grant supported staff members are currently teaching courses at the graduate level. Through providing new and improved laboratory facilities, audiovisual equipment, increased library resources and increased staff personnel, the grant has enchanced the quality of teaching at UPR/MC. At present, 25 graduate students are working toward the M.S. degree in Crop Protection and the number of students developing interest in the field is continually increasing.

Teaching and research facilities have been significantly improved under this grant. New laboratory facilities, including green houses, have been developed at the College Farm (La Finca). These facilities are currently available to staff and students. Laboratory facilities on campus for plant pathology and nematology have also been developed and made available to staff and students. The development of these facilities has had a direct effect upon the development of UPR/MC institutional response capability. At present, UPR/MC is capable and willing to provide education, training, and consultation to LDCs of the tropics in protection and production of soybean and other food legumes.

Grant funds have been used to provide travel support for staff members. This provides two major benefits for the insitution and the program: 1) the broadening of professional experience and expertise and 2) the development of linkages and establishment of new joint research projects.

F. Other Resources for Grant Related Activities

Funds provided under this grant have never been used to replace existing funds for other university projects. Activities conducted under this grant have been designed to complement and strengthen existing programs.

In direct support to the grant, UPR/MC has provided and will continue to provide:

1. Administrative costs including salaries and utilities in administrative offices. The project director, Dr. M. A. Ellis receives an administrative bonus of $200.00 per month. This amounts to $2,400.00 per year that the grant is paying for administrative salaries. No funds from the grant are used to cover costs of services or senior administrative officers in the College of Agricultural Sciences.

2. Class rooms, library, field space and facilities, office space, and laboratory space and utilities have also been provided to grant personnel by UPR/MC. All facilities available through the Agricultural Experiment Station have been made available to grant personnel and grant related activities. The services of the Central Anolytical Laboratory of the Agricultural Experiment Station, the soil testing laboratory at the Mayaguez campus and the Nuclear Center have also been made available to grant personnel and projects at no charge to the project. These costs (contributions) are very difficult to assess. They are roughly equivalent to the overhead charges for a research contract.

In order to develop institutional response capability in the area of tropical crop protection of soybean and other food legumes, UPR/MC has spared no expense and has always given 100% support to the program developed under this grant.

No other sources of funding have been made available to this program.

G. Utilization of Institutional Response Capabilities in Development Programs

It should be pointed out that prior to receiving this grant, soybeans were of no commercial importance to Puerto Rico and UPR/MC. Therefore, the institutional response capability of UPR/MC in tropical crop protection of soybean was very limited. For the above mentioned reason requests for assistance from tropical LDCs have been few. Since the beginning of the grant, UPR/MC has worked to develop its institutional response capabilities in this area. At present, UPR/MC has developed and is continuing to develop significant response capabilities.

Through the development and demonstration of UPR/MC response capability, the number of requests for assistance has significantly increased during the reporting period and it is anticipated that the number of requests will continue to increase as interest in the tropical production of soybean increases.

Requests for assistance during this reporting period have been presented and discussed under Part D Accomplishments (Output II Education and Training and Output III Advisory Capacity) of this report.

H. Plan of Work and Anticipated Expenditures for Years I and II of the Grant Extension

Since the inception of this grant first priority has been given to the development of a strong research program and the establishment of education and training facilities and staff in the area of tropical crop protection of soybean and other food legumes. This priority ranking will be slightly changed for the remainder of the funding period. Future program emphasis will be placed on the utilization of developed institutional response capabilities in development programs.

The continuation of the on going research program will maintain a position of high priority in the last year of the grant. The maintenance of a high quality research program provides the following primary functions:

1) the development of needed technology in the area of tropical crop protection of soybean;
2) the continued development of staff expertise and knowledge in the problem area; and
3) the demonstration of UPR/MC institutional response capability in the problem area.

Included for funding in the two year grant extension, is program expansion in the areas of entomology and nematology.

Dr. Nelia Acosta has recently received her Ph.D in nematology at UIUC. Dr. Acosta was involved in the grant supported student exchange program between UPR/MC and UIUC. Her return to UPR/MC has facilitated the incorporation of the nematology component into the present program. The development of response capability in tropical nematology of soybean has received funding in year V of the grant and will continue to receive funding under the two year grant extension. Dr. Acosta has initiated research in control of nematodes in soybean under tropical conditions. The research has recently been initiated and to date no results have been collected. The results of Dr. Acosta's first year of research will be presented in next year's annual report. At present, the grant is providing 20% of Dr. Acosta's salary.

The area of entomology continues to be of primary interest to future program development at UPR/MC. At present, we have developed significant response capability in the areas of plant pathology, weed science and seed pathology. Response capability is currently being developed in the area of nematology.

When entomology is included into the grant program, a well-rounded tropical crop protection research, advisory and training team will be established. UPR/MC will be ready and capable of responding to most requests for aid in tropical crop protection of soybeans. Funding for the entomology component has been provided by A.I.D. in the two year grant extension. A job description for an INTSOY entomologist at UPR/MC has been written and distributed. Arrangements are currently being made to interview candidates for the position. Hopefully, the entomologist will be on board around January 1979.

Continued development and maintenance of facilities for research and training will receive program support and funding. Of special interest to this program, is the establishment and continued development of the newly founded Department of Crop Protection.

Full program support will be given to pertinent graduate student research. In addition, A.I.D. has provided funding for two graduate assistantships. Assistantships will be provided within the Department of Crop Protection for research on tropical crop protection of soybean.

Continued development of informational research and informational linkages will be supported. In all grant related activities, our primary linkage with UIUC will be continued. UIUC has truly distinguished itself as the leading institution in world soybean development. Through cooperation and planning with UIUC and other linked institutions and organizations, the basis for a truly international network of organizations and individuals which can sustain future soybean development programs for the tropics has been developed.

As funding permits, all requests for assistance from LDCs will be answered.

The development of literature (in Spanish and English) based on current knowledge and results from program research will receive funding during the last year of the grant.

Individual work plans by objective and activity for years I and II of the grant extension are included. A summary work plan by objective, activity and cost for years I and II of the grant extension is presented below:

1. Summary work plan by objective, activity and cost for Year I and II of the proposed extension.

	Year I		Year II	
Objective I--Expanded knowledge base	Activity	Objective	Activity	Objective
and research capability		$124,676		$126,926
A-1 Seed pathology and production of high quality seed	$27,551.52		$28,051.52	
A-2 Plant Pathology of Soybean under tropical conditions	22,420.00		22,920.00	
A-3 Weed Science	32,860.00		33,360.00	
A-4 Tropical Nematology of Soybean	12,000.00		12,250.00	
A-5 Tropical Entomology of Soybean (to be incorporated in year 1 of proposed grant extension)	29,844.48		30,344.48	

Note: Expenditures listed under Objective 1 include salaries and fringe benefits for all grant personnel except the grant program director and secretary. Salaries of the program director and secretary are included under Objective III Advisory Capacity.

	Year I		Year II	
	Activity	Objective	Activity	Objective
Objective II--Education and training		$13,000.00		$13,074.00
A-1 Continued development of training and education capacity within the Department of Crop Protection UPR/MC	$1,000.00		$1,000.00	
A-2 Graduate assistantships	11,000.00		11,074.00	
A-3 Travel and support for work-study training program	1,000.00		1,000.00	

	Year I		Year II	
	Activity	Objective	Activity	Objective
Objective III--Advisory Capacity		$16,000.00		$16,000.00
A-1 Maintenance and continued development of staff personnel which can act as an advisory team in tropical Crop Protection of soybean	$9,000.00		$9,000.00	
A-2 Travel in response to requests, for aid in development	7,000.00		7,000.00	
Objective IV--Information Capacity		6,000.00		6,000.00
A-1 Publishing of grant supported research results and other grant supported publications	6,000.00		6,000.00	
Objective V--Linkages and Networks		8,000.00		8,000.00
A-1 Travel	5,000.00		5,000.00	
A-2 Administrative and research support	3,000.00		3,000.00	
	Total Year I	$167,676.00	Total Year II	$170,000.00

2. Individual work plans by objective and activity for Year I and II of the Grant extension.

WORK PLANS FOR UNIVERSITY OF PUERTO RICO 211(d) GRANT--

DEVELOPING RESPONSE CAPABILITY IN SOYBEANS FOR LDCs OF TROPICS AND SUBTROPICS

Output No. I

Program subcategory No. I Activity Seed pathology and the production of high quality seeds under tropical conditions.

Staff to be involved Seed pathologist, plant pathologist, plant breeder and laboratory technician.

Scheduled events Continued development and application of needed technology in the area of tropical production of high quality disease-free seed.

Expected results A significant increase in knowledge and training capability in the problem area.

Costs	Year I	Year II
Personnel	$21,551.52	$22,061.00
Travel	2,000.00	2,000.00
Research support	4,000.00	4,000.00
Subcategory total	27,551.52	28,051.52

WORK PLANS FOR UNIVERSITY OF PUERTO RICO 211(d) GRANT--

DEVELOPING RESPONSE CAPABILITY IN SOYBEANS FOR LDCs OF TROPICS AND SUBTROPICS

Output No. I Expanded Knowledge Base and Research Capability

Program subcategory No. II Activity Plant pathology of soybean under tropical conditions.

Staff to be involved Plant pathologist, seed pathologist, plant breeder and one full-time technician.

Scheduled events Continued identification of soybean diseases present in Puerto Rico. Screening tropically adapted soybean cultivars for resistance to selected foliar and root rotting diseases.

Expected results Identification of soybean germplasm with resistance to selected plant diseases.

Costs	Year I	Year II
Personnel	$15,420.00	$15,920.00
Travel	2,000.00	2,000.00
Research support	5,000.00	5,000.00
Subcategory total	22,420.00	22,920.00

WORK PLANS FOR UNIVERSITY OF PUERTO RICO 211(d) GRANT--

DEVELOPING RESPONSE CAPABILITY IN SOYBEANS FOR LDCs OF TROPICS AND SUBTROPICS

Output No. I Expanded Knowledge Base and Research Capability

Program subcategory No. III Activity Weed science-control and study of weed species commonly associated with soybeans in the tropics.

Staff to be involved Weed scientist, one full-time technician and plant breeder.

Scheduled events Continued research in methods of controlling weeds in soybeans under tropical conditions, and competitive ability of common weed species against soybean.

Expected results Significant increase in knowledge and training capability in tropical weed control in soybean.

Costs	Year I	Year II
Personnel	$25,860.00	$26,360.00
Travel	2,000.00	2,000.00
Research support	5,000.00	5,000.00
Subcategory total	32,860.00	33,360.00

WORK PLANS FOR UNIVERSITY OF PUERTO RICO 211(d) GRANT--

DEVELOPING RESPONSE CAPABILITY IN SOYBEANS FOR LDCs OF TROPICS AND SUBTROPICS

Output No. I Expanded Knowledge Base and Research Capability

Program subcategory No. IV Activity Tropical nematology of soybean

Staff to be involved Nematologist and plant pathologist.

Scheduled events Initiation of research on the effect of nematodes on tropical soybean production, and methods for their control. Development of research and training facilities in tropical nematology.

Expected results Development of institutional response capability in the area of tropical nematology of soybean.

Costs	Year I	Year II
Personnel	$ 5,000.00	$ 5,250.00
Travel	2,000.00	2,000.00
Research support	5,000.00	5,000.00
Subcategory total	12,000.00	12,250.00

WORK PLANS FOR UNIVERSITY OF PUERTO RICO 211(d) GRANT--

DEVELOPING RESPONSE CAPABILITY IN SOYBEANS FOR LDCs OF TROPICS AND SUBTROPICS

Output No. I

Program subcategory No. V Activity Tropical entomology of soybean

Staff to be involved UPR/MC entomologist (current not employed), INTSOY entomology staff at UIUC and plant breeder.

Scheduled events Development of a research program and institutional response capability in the area of entomology. Development of pest management programs for soybeans in the tropics.

Expected results Development of institutional response capability in soybean entomology under tropical conditions.

Costs	Year I	Year II
Personnel	$18,000.00	$18,500.00
Travel	2,000.00	2,000.00
Research support	9,844.48	9,844.48
Subcategory total	29,844.48	30,344.48

WORK PLANS FOR UNIVERSITY OF PUERTO RICO 211(d) GRANT--

DEVELOPING RESPONSE CAPABILITY IN SOYBEANS FOR LDCs OF TROPICS AND SUBTROPICS

Output No. II Education and Training Capability

Program subcategory No. I Activity Education and training within the department of crop protection (UPR/MC). Graduate student research support and international work-study training program.

Staff to be involved All grant personnel and grant program director.

Scheduled events Continued teaching and graduate student advising on the part of all grant personnel. Support for pertinent graduate student research. Support for work-study trainee from Peru.

Expected results Continued development, and utilization of institutional response capability in the area of education and training of tropical crop protection.

Costs	Year I	Year II
Personnel	$ --	$ --
Travel	2,000.00	2,000.00
Other program support	11,000.00	11,074.00
Subcategory total	13,000.00	13,074.00

All grant personnel will be used in grant supported education and training activities as needed to meet program objectives.

WORK PLANS FOR UNIVERSITY OF PUERTO RICO 211(d) GRANT--

DEVELOPING RESPONSE CAPABILITY IN SOYBEANS FOR LDCs OF TROPICS AND SUBTROPICS

Output No. III Advisory capacity

Program subcategory No. I Activity Maintenance and continued development of staff personnel which can serve as an international advisory team in the area of tropical crop protection of soybean.

Staff to be involved All grant personnel and grant program director.

Scheduled events Maintenance of present grant personnel and continued development of grant personnel. Special emphasis will be given to entomology and nematology.

Expected results The development of a well rounded advisory team in the area of tropical crop protection of soybean.

Costs	Year I	Year II
Personnel	$ 9,000.00	$ 9,000.00
Travel	7,000.00	7,000.00
Research support	--	--
Subcategory total	16,000.00	16,000.00

Salaries listed above included the grant program director 0.2 Fte and the program secretary 1.0 Fte. All grant personnel will be used in grant supported advisory activities as needed to meet program objectives.

WORK PLANS FOR UNIVERSITY OF PUERTO RICO 211(d) GRANT--

DEVELOPING RESPONSE CAPABILITY IN SOYBEANS FOR LDCs OF TROPICS AND SUBTROPICS

Output No. IV Information Capacity

Program subcategory No. I Activity Publishing of all research results obtained through this program. Funding of program publications in soybean protection under tropical conditions.

Staff to be involved All grant personnel and grant program director.

Scheduled events Publication of grant supported research results. Publication of extension-type bulletins related to the tropical crop protection of soybean.

Expected results Presentation (in English and Spanish) of significant program research findings and current knowledge in the area of tropical crop protection of soybean.

Costs	Year I	Year II
Personnel	$ --	$ --
Travel	--	--
Publication costs	6,000.00	6,000.00
Subcategory total	6,000.00	6,000.00

WORK PLANS FOR UNIVERSITY OF PUERTO RICO 211(d) GRANT--

DEVELOPING RESPONSE CAPABILITY IN SOYBEANS FOR LDCs OF TROPICS AND SUBTROPICS

Output No. V Linkages and networks

Program subcategory No. I Activity Continued development of linkages with international research centers and other organizations. Linkages with tropical LDCs in the areas of research, education and training.

Staff to be involved All grant personnel and the grant program director.

Scheduled events Continued development of informational and research linkages with international organizations and LDCs institutions.

Expected results The development of an international network of organizations and individuals which can sustain future soybean development programs in the tropics.

Costs	Year I	Year II
Personnel	$ --	$ --
Travel	5,000.00	5,000.00
Other program support	3,000.00	3,000.00
Subcategory total	8,000.00	8,000.00

I. Involvement of Minority Personnel and Women

The grant has provided opportunities for employment of women. The program secretary and one research assistant are women. In addition, the program nematologist (Dr. Nelia Acosta) is a woman.

The University of Puerto Rico is an affirmative action, equal opportunity employer.

Table I. Distribution of 211(d) Grant Funds and Contributions From Other Sources of Funding*

Reporting Period October 1, 1977 to September 30, 1978

Grant Objectives/Outputs	Period Under Review	Cumulative Total	Projected Next Year	Projected to end of Grant	Non 211(d) Funding* Amount from UPR/MC
I. Expanded Knowledge Base	62,000.00	260,513.77	124,676.00	251,602.00	40,000.00
II. Education and Training	40,000.00	177,421.18	13,000.00	26,074.00	32,000.00
III. Information Capacity	10,000.00	21,958.36	6,000.00	12,000.00	
V. Linkages and Advisory Capacity	9,851.47	40,106.69	24,000.00	48,000.00	
Total	121,851.47	500,000.00	167,676.00	337,676.00	72,000.00

* These figures are our best estimates.

Table II

211(d) Expenditure Report

Actual and Projected Summary

Under Institutional Grant #AID/ta-G-50

	Expenditures to date		Projected Expenditures For Two Year Grant Extension
	Reporting Period	Cumulative Total	
Salaries	70,000.00	293,313.46	175,860.00
Employees Benefit	13,000.00	35,714.86	31,654.00
Travel & Subsistence	15,000.00	68,429,28	34,000.00
Supplies & Materials	15,851.47	52,142.86	36,000.00
Research Support	8,000.00	50,399.54	38,088.00
Fellowships	----	----	22,074.00
Total	127,851.47	500,000.00	337,676.00

Table III. 211(d) Expenditure Report Reporting Year Detail
Under Institutional Grant #AID/tg-G-50

Reporting Period October 1, 1977 to September 30, 1978

		Percentage Time	Amount
I.	Salaries		
	A. Academic		
	Grant Director	20	$ 1,200.00
	M. Ellis	30	4,431.48
	P. Melendez	50	11,872.32
	R. Riveros	100	20,760.00
	N. Acosta	20	3,208.00
	E. Rosario	100	9,600.00
	B. Clerical		6,000.00
	C. Technical Aids (2)		12,928.20
	D. Employees Benefits		13,000.00
II.	Travel		
	A. Domestic		4,000.00
	B. Foreign		8,997.00
III.	Materials & Supplies		15,605.00
IV.	Equipment		8,000.00
V.	Graduate Student Research Support		2,249.47
	Total		$121,851.47

APPENDIX A

ASSOCIATED RESEARCH

1. Inheritance of resistance to Soybean Mosaic Virus

A study to determine the inheritance of resistance to soybean mosaic virus (SMV) in soybeans is being conducted at Isabela, Puerto Rico. A diallele set of crosses has been made between the resistance parents Buffalo, P.I. 324.068, P.I. 341.242, P.I. 374.193, and the susceptible parents Jupiter and Hardee Late Selection. A cross has also been made between Buffalo and P.I. 96.983. P.I. 96.983 is a SMV resistant line whose genetics have been worked out with respect to resistance to one isolate of SMV. Populations of F_1 and F_2 plants for 8 of the crosses have been planted in the field. Each F_1 and F_2 population has been divided into 6 samples with each sample inoculated with a different isolate of SMV. Different isolates are being used because not all resistant parents are resistant to the same SMV isolates.

2. The effect of seedling vigor on soybean nodulation by *Rhizobium japonicum*

Research has been completed in cooperation with Dr. R. Stewart Smith (University of Illinois stationed at University of Puerto Rico) investigating the effects of soybean seedling vigor on the amount and location of nodulation. Preliminary results from this study were reported in the previous annual report of Grant AID/CM/ta-G-73-50, University of Puerto Rico.

Field experiments were conducted using seeds of three soybean cultivars (Jupiter, SJ-1 and Orba) which were adjusted using the accelerated aging technique in order to provide seed lots of each cultivar with a high degree of variation in seedling vigor. Aged seeds were uniformly inoculated in the furrow with a *Rhizobium japonicum* liquid inoculum. Reduced seedling vigor within each cultivar was positively correlated with reduced plant size, number of tap root nodules, total number of nodules and nodule dry weight per plant. Significant decreases in the number of tap root nodules and total number of nodules were observed between each of the three earliest emerging treatments in a sandbench trial. In 79% of the instances there were significantly more tap root nodules, total number of nodules and nodule dry weight per plant on the earliest emerging treatment than on the latest emerging treatment. The number of tap root nodules was more closely correlated to seedling vigor than were total number of nodules or nodule weight.

This study indicates that the amount of early nodulation is influenced by the seedling vigor. As the length of time from planting to seedling emergence increased the number of tap root nodules, total number of nodules and nodule weight per plant decreased. In general, there were more instances of significance and higher negative correlation coefficients between the number of days to emerge and the number of tap root nodules than between the number of days to emerge and total number of nodules or nodule weight per plant. This

indicates that tap root nodulation is influenced more by seedling vigor than are total number of nodules or nodule weight per plant.

This study suggests that experiments intended to evaluate the amount of initial soybean nodulation should utilize seedlings of uniform vigor. This may assist in reducing undesirable variables in studies involving the symbiotic relationship between soybean and *Rhizobium japonicum*.