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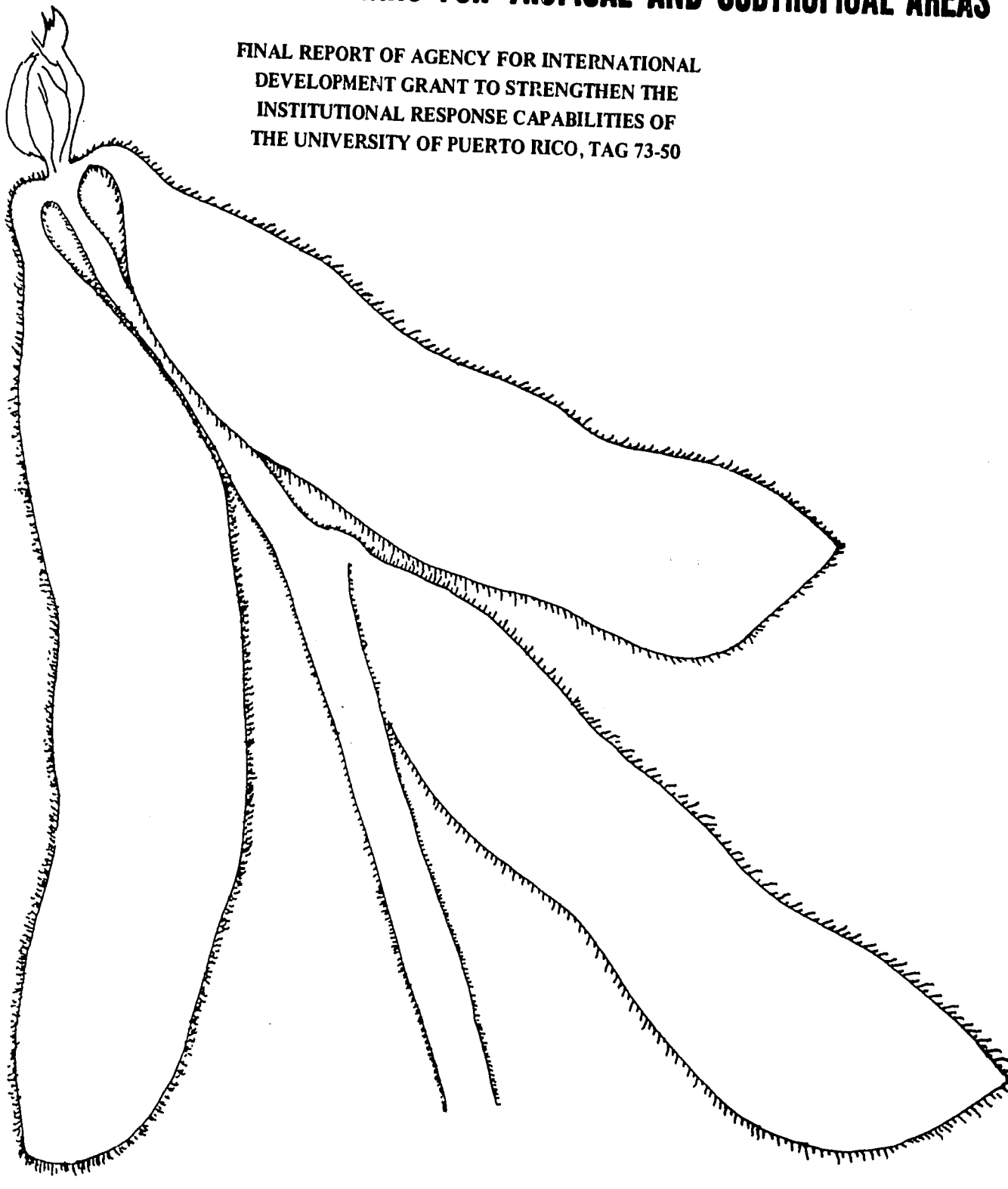
CROP PROTECTION OF SOYBEANS FOR TROPICAL AND SUBTROPICAL AREAS

FINAL REPORT OF AGENCY FOR INTERNATIONAL DEVELOPMENT GRANT TO STRENGTHEN THE INSTITUTIONAL RESPONSE CAPABILITIES OF THE UNIVERSITY OF PUERTO RICO, TAG 73-50



INTERNATIONAL SOYBEAN PROGRAM (INTSOY)

DEPARTMENT OF CROP PROTECTION
COLLEGE OF AGRICULTURE SCIENCES
UNIVERSITY OF PUERTO RICO AT MAYAGUEZ

1979 - 1980

PDAAT-787

A GRANT TO STRENGTHEN THE COMPETENCE OF THE UNIVERSITY OF PUERTO RICO IN DISEASES AND PEST CONTROL AND RELATED CULTURAL PRACTICES FOR SOYBEANS AND OTHER FOOD LEGUMES FOR TROPICAL AND SUBTROPICAL AREAS

UNIVERSITY OF PUERTO RICO
MAYAGUEZ CAMPUS

BY

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TO

AID Sponsoring Technical Office: TA/AGR

SUBMITTED

APRIL 1981

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A. STATISTICAL SUMMARY

Period of Grant: September 16, 1973 to September 16, 1980
Total Amount of Grant: $837,676.
Expenditures:

a)	Report Period	$128,931.10
b)	Accumulated	$822,947.27
c)	Anticipated	$ 14,728.73

B. NARRATIVE SUMMARY

For the period September 16, 1973 to September 16, 1978, the University of Puerto Rico at Mayaguez was granted $500,000 (AID/CM/ta-g-73-50) for developing its competence for research, teaching, and extension in the area of crop protection of soybean and other grain legumes in tropical areas. A two year extension was given to the original grant for the period September 17, 1978 to September 16, 1980. An extension without additional funding was given for the period September 17, 1980 to December 31, 1980 to help complete all unfinished business. This is the final grant report.

From its inception, this grant has collaborated with the University of Illinois. Three of the four investigators in the final grant period received their training at the College of Agriculture, Department of Plant Pathology, at the University of Illinois. The Puerto Rico grant was a sister grant which launched an organization known as INTSOY (International Soybean Program) the aim of which was to promote tropical production of soybeans. The University of Puerto Rico program concentrated on research, extension, and teaching in the area of crop protection. The University of Illinois program has concentrated on breeding and information retrieval to help lesser developed countries interested in soybean cultivation. Grant personnel interacted intimately with the soybean breeder from INTSOY (University of Illinois) who is stationed in Puerto Rico. Puerto Rico offers a variety of tropical climates, representative tropical soils, varied pests, and close proximity to both the lesser developed tropical areas and advanced areas in the United States. Puerto Rico has thus served as a critical link in the adaptation of soybean technology and germplasm to the tropics, especially Latin America.

During the grant period, the University of Puerto Rico at Mayaguez developed a Department of Crop Protection. Grant staff belongs to this department and has worked to foster an integrated approach to pest management. Grant staff have offered courses in Plant Disease Diagnosis, Plant Pathology, Nematology, Mycology and Weed Science. They also have been active in advising graduate students from lesser developed countries in Latin America and from Puerto Rico at the Master's of Science level.

Because it is the only U.S. land grant institution with both tropical climate and ability to teach in Spanish, the University of Puerto Rico has an unique ability for international training and outreach. Under the grant many linkages

were established with state, national and international organizations. The staff have participated in training and outreach activities throughout Latin America and have been advising and teaching graduate students from Bolivia, Colombia, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama and Puerto Rico.

C. DETAILED REPORT

Malnutrition affects as many as 1.5 to 2.0 billion people worldwide. The most common form of malnutrition develops from diets with insufficient protein. Sufficient balanced proteins are essential for growth. Children deficient in this component become stunted and mentally retarded. For these reasons, solutions of protein deficiency must be sought.

Food legumes, such as soybean (*Glycine max*), field bean (*Phaseolus vulgaris*), cowpea (*Vigna sinensis*) and pigeon pea (*Cajanus cajan*), are excellent sources of inexpensive high quality proteins. Food legumes are grown extensively in the tropics. Yields, however, are extremely low. Soybean has an advantage over other grain legumes in higher protein content, higher protein quality, higher yield potential and short production period. Of the factors limiting tropical legume production a variety of pests (fungi, bacteria, viruses, mycoplasmas, insects nematodes and weeds) are prominent. Increased and sustained production of grain legumes in tropical areas is unlikely without development and application of crop protection measures.

Grant objectives focus on the development and improvement of the University of Puerto Rico's institutional response capacity in the area of tropical crop protection of soybean and other grain legumes. The development of background knowledge through research optimizes staff effectiveness in teaching and in outreach activities.

Major objectives are:

I. Expanding the research base to solve crop protection problems on soybean and other grain legumes in the tropics.

II. Improving the University of Puerto Rico's educational capability by utilizing expertise gained under the research program.

III. Increasing the advisory ability of the University of Puerto Rico by the development of a coordinated and interdisciplinary team of researchers in crop protection of soybean and other grain legumes in the tropics.

IV. Expanding research and information linkages to stimulate increased production of soybean and other grain legumes in the tropics.

I. RESEARCH ACCOMPLISHMENTS

A strong research program is viewed as a prerequisite for solution of crop protection deficiencies in grain legumes in the tropics. Most previous research has centered on problems developing in temperate areas. This research from

temperate areas may not be directly applicable to the tropical problems. Institutions and individuals in lesser developed countries should look to training and consultation to tropical institutions where research expertise can be directly applied.

a. WEED SCIENCE (Guillermo Riveros)

Work that has been conducted under this grant has permitted the selection of herbicides and herbicide combinations which are both selective and effective for oxisols and vertisols, two of the most common tropical soils. Weed species associated with different soil types in Puerto Rico vary. These weed communities are similar to those existing in other tropical sites with similar soils and quite different than those commonly occurring in temperate areas. Results have shown that soybeans which are planted in May or June need to be free of weeds for the first four weeks to avoid serious yield losses. Yield losses when weeds are not controlled varies depending on season. Losses averaged from 70 to 90% during the rainy season and from 15 to 20% during the dry season. Work with program plant pathologists has shown that weeds can also stimulate the development of soybean diseases and result in serious losses in seed quality. Time of critical competition varies depending on soybean variety and different soybean varieties have different tolerances to weed competition. Earlier varieties with a shorter period of growth experience the critical competition earlier in their development. Yield reductions are greater when soybeans are planted in 60 cm rows than in 30 or 45 cm rows. Wider row spacing was shown to delay shading and permit more light availability for weeds.

Studies were conducted on the selectivity of metribuzin in soybeans. These showed that application of this herbicide in humid soils and after light irrigation can increase selectivity. Proper water management was shown to lessen vertical movement of the herbicide in light soils and accumulation in furrows in heavy soils. Ridge planting increased the selectivity of metribuzin in heavy soils and increased planting depth increased selectivity of the herbicide on both light and heavy soils.

Work which was completed or started during the last grant period was the following.

1. Soybean Herbicide Evaluation

An experiment was conducted at the Fortuna substation (mollisol) to evaluate herbicides that gave good results in previous trials at Isabela (oxisol) and Lajas (vertisol). Differences in the dominant weed species were found for the three sites and herbicides had varying effectiveness depending on dominant weeds at the various experimental sites.

Improved Pelican soybean seed were drilled in 60 cm rows at a rate of about 20 seeds per meter row on June 30th. Granular inoculum of *Rhizobium japonicum* was provided in the planter box at a rate of about 3.6 g per 6.0 m row. Herbicide treatments (Table 1) were arranged in a randomized complete block design with 3 replications. Plots were 2.4 m wide and 6.0 m long. Preplant incorporated treatments were sprayed June 30th and incorporated with hand rakes at a depth of about 3 cm. The preemergence treatments were applied

July 1st and the postemergence treatments on July 15th. Herbicides were delivered with a precision compressed carbon dioxide field plot sprayer at a pressure of 2.1 kg per cm^2 equipped with 8004 nozzles delivering an equivalent of 200 liters per hectare.

The granular formulation of cyanazine was mixed with fine sand sufficient to cover the experimental plot. The experiment was watered by an overhead irrigation system July 1st and as needed afterwards. Predominant weeds were: jimson weed (*Datura stramonium*), spider flower (*Cleome spinosa*), horse purslane (*Triantema portulacastrum*), jungle rice (*Echinochloa colonum*), and red spangled top (*Leptochloa filiformis*).

Hand weeded check plots were hoed July 15th and 30th and August 15th. The whole experiment was hand weeded August 30th.

Herbicide injury to the crop was estimated visually July 15th and 30th, using a scale from 0 to 10. On the same dates the percent of weed control of the herbicide treated plots was also estimated in comparison with the unweeded plots. At the latter date weed samples were taken from each by throwing a 25 by 50 cm frame 3 times. The weed samples were placed in paper bags and taken to the laboratory for counting and weighing. The inner two rows were harvested October 27th for recording grain yields.

RESULTS AND DISCUSSION

Slight toxicity was observed on July 15th in plots treated with cianazine + alachlor (1.0 + 1.0) using the wettable powder and flowable formulation of cyanazine and also in the plots treated with trifluralin (Table 1). Light toxicity (2 to 3 ratings) was observed in plots treated with the flowable formulation of cyanazine at the rate of 2.0 kg/ha plus alachlor at 1 kg/ha, followed by the treatments of metribuzin at 0.5 applied preemergence with either alachlor, linuron or the trifluralin preplant incorporated, and with the granular formulation of cyanazine plus alachlor at the rate of 1.0 and with the granular formulation of cyanazine or wettable powder at 2.0 kg per ha.

Moderate toxicity (3.1 to 4.0) was registered from plots that received metribuzin 0.75, vernolate and metribuzin at 3.0 plus 5.0, and with the granular formulation of cyanazine at the rate of 2.0 plus alachlor. The granular formulation of cyanazine gave higher toxicity ratings than the wettable powder or the flowable liquid. This was possibly due to uneven distribution in the field. Severe toxicity was observed in the plots treated with oxifluorofen at 0.75.

The evaluation performed July 30th revealed only light symptoms of toxicity for all treatments indicating that the soybeans had recovered from the initial injury. Higher ratings were still observed in the plots treated with oxyfluorfen. Of the postemergence treatments acifluorfen caused only moderate toxicity. MO 70077 at 1.0 and 2.0 and bentazon caused only slight toxicity symptoms.

The evaluation of the preemergence and preplant incorporated treatments performed at two weeks after their application revealed that over 80% of the weeds were controlled in all treatments except trifluralin 1.5 and with alachlor plus cyanazine (1.0 + 1.0), and with the wettable powder formulations of cyanazine which had about 70% control. At four weeks complete weed control was observed

in the plots treated with oxyfluorfen 0.75, metribuzin plus alachlor (0.5 + 1.0), and excellent to very good control was found from metribuzin 0.75 and for metribuzin plus vernolate (0.5 + 3.0). Good to satisfactory weed control was registered in the plots which received alachlor plus cyanazine granular (1.0 + 1.0), alachlor plus cyanazine wettable powder plus alachlor (2.0 + 1.0), linuron plus metribuzin (1.0 + 0.5) and trifluralin + metribuzin (1.0 + 0.5). The other treatments all gave less than satisfactory control.

Treatments significantly reducing weed counts at 4 weeks are given in order of lowest to highest in Table 2. These were: oxyfluorfen 0.75, alachlor plus metribuzin (1.0 + 0.5), linuron plus metribuzin (1.0 + 0.5) and cyanazine wettable powdery. The lowest weed weights were found for oxyfluorfen 0.75 followed by cyanazine plus alachlor (2.0 + 1.0), vernolate plus metribuzin (3.0 + 0.5), metribuzin alone 0.75, cyanazine plus alachlor (2.0 + 1.0) and alachlor plus metribuzin (1.0 + 0.5).

Jimson weed was effectively controlled by oxyfluorfen 0.75, bentazon 1.5, MO 70077 2.0, metribuzin 0.75, vernolate plus metribuzin (3.0 + 0.75), alachlor plus metribuzin (1.0 + 0.5), linuron plus metribuzin (1.0 + 0.5), acifluorfen 0.75, MO 70077 1.0, and cyanazine granular plus alachlor (2.0 + 1.0).

Spider flower was abundant only in the plots treated with trifluralin (1.5) and trifluralin plus metribuzin (1.0 + 0.5). It was collected from plots treated with oxyfluorfen. Cyanazine, bentazon, acifluorfen, and vernolate plus metribuzin effectively controlled this weed.

Low amounts of horse purslane were registered in plots where jimson weed and spider flower were abundant. When these two species were controlled the amounts or horse purslane increased sharply. Treatments that prevented such an increase were oxyfluorfen 0.75, metribuzin 0.75, and metribuzin in combination with vernolate and alachlor.

Postemergence treatments of acifluorfen, MO 70077 and bentazon did not control horse purslane possibly because jimson weed and spiderflower prevented herbicide to weed contact.

Good control of grasses was provided by oxifluorfen 0.75 and by most of the treatments in which either trifluralin or alachlor were included.

Higher soybean grain yield was found in plots treated with oxyfluorfen 0.75. Other treatments were not significantly different from the handweeded check.

Although oxyfluorfen caused severe injury to soybean at early seedling stages, it also provided excellent weed control and the highest yields. Under the conditions of this study, weed competition was more detrimental to yield than the toxicity of this herbicide.

Table 1: Soybean herbicide evaluation - Fortuna 1980.
Weed number and weed weight at 4 weeks after planting and yield.

Herbicide	Rate kg/h	Time of Application	Injury Ratings at week 2	Injury Ratings at week 4	% Total Weed Control at Week 2	% Total Weed Control at Week 4	Yield kg/h
Trifluralin	1.5	PPI	1.7	1.0	68	60	1282
Trifluralin / Metribuzin	1.0 / 0.5	PPI	2.6	1.7	92	83	1701
Metribuzin	0.75	PREEM	3.3	1.3	97	92	2187
Vernolate / Metribuzin	3.0 / 0.75	PPI	3.3	1.3	97	90	2374
Alachlor / Metribuzin	1.0 / 0.5	PREEM	2.2	1.3	98	100	2245
Linuron / Metribuzin	1.0 / 0.5	PREEM	2.7	1.3	90	85	2429
Oxyfluorfen	.75	PREEM	8.3	3.0	100	100	2795
Acifluorfen	.75	POST	---	3.3	--	50	1753
Cyanazine WP / Alachlor	1.0 / 1.0	PREEM	.6	.7	72	60	1727
Cyanazine WP / Alachlor	2.0 / 1.0	PREEM	3.0	1.0	90	87	1916
Cyanazine 15G / Alachlor	1.0 / 1.0	PREEM	3.0	1.0	85	83	1972
Cyanazine 15G / Alachlor	2.0 / 1.0	PREEM	4.0	1.7	90	77	1592
Cyanazine 4F / Alachlor	1.0 / 1.0	PREEM	1.7	0.0	87	60	1022
Cyanazine 4F / Alachlor	2.0 / 1.0	PREEM	2.3	0.3	85	73	2041
MO 70077	1.0	POST	---	1.7	--	40	1632
MO 70077	2.0	POST	---	2.3	--	53	1253
Bentazon	1.5	POST	---	2.0	--	37	1233
Non-weeded check					--	--	966
Hand-weeded check					--	--	2555
						LSD 0.5	953

Table 2: Soybean herbicide evaluation - Fortuna 1980.
Weed number and weed weight at 4 weeks after planting.

Herbicide	Rate kg/h	Time of Application	Weed Number					Weed Weight gr/.375 m^2				
			A	B	C	D	Total	A	B	C	D	Total
Trifluralin	1.5	PPI	---	9.3	4.0	.7	14.0	---	328.7	178.7	41.7	549.1
Trifluralin / Metribuzin	1.0 / 0.5	PPI	3.7	1.3	3.7	1.7	10.4	42.3	215.7	195.3	178.0	631.3
Metribuzin	0.75	PREEM	4.3	.3	.3	.3	5.2	217.1	8.7	30.0	63.0	318.8
Vernolate / Metribuzin	3.0 / 0.5	PPI	6.3	2.7	.3	2.0	11.3	179.0	18.4	7.7	72.3	277.4
Alachlor / Metribuzin	1.0 / 0.5	PREEM	1.0	1.7	.3	1.9	4.9	57.0	22.0	32.3	78.0	189.3
Linuron / Metribuzin	1.0 / 0.5	PREEM	2.7	.7	.3	2.3	6.0	185.0	24.3	24.7	376.0	610.0
Oxyfluorfen	.75	PREEM	2.3	---	---	---	2.3	54.0	---	---	---	54.0
Acifluorfen	.75	POST	7.7	8.0	2.0	4.6	22.3	391.3	44.0	7.0	277.0	719.3
Cyanazine WP / Alachlor	1.0 / 1.0	PREEM	1.3	14.3	---	.3	15.9	33.0	677.0	---	5.0	715.0
Cyanazine WP / Alachlor	2.0 / 1.0	PREEM	2.7	2.0	.7	.7	6.1	21.6	138.3	2.0	14.0	175.9
Cyanazine 15G / Alachlor	1.0 / 1.0	PREEM	3.0	6.0	---	2.3	11.3	103.2	143.3	---	190.0	436.5
Cyanazine 15G / Alachlor	2.0 / 1.0	PREEM	1.0	2.3	.7	7.0	11.0	23.7	47.4	4.0	833.1	908.2
Cyanazine 4F / Alachlor	1.0 / 1.0	PREEM	2.0	3.3	.7	5.3	11.3	37.4	151.7	50.0	475.5	714.6
Cyanazine 4F / Alachlor	2.0 / 1.0	PREEM	4.3	3.6	---	1.7	9.6	93.1	113.5	16.7	110.0	316.6
MO 70077	1.0	POST	16.3	4.3	1.0	5.2	26.9	263.0	45.3	36.0	233.3	558.3
MO 70077	2.0	POST	8.7	.3	3.0	4.0	16.0	284.7	5.2	1.3	110.8	436.7
Bentazon	1.5	POST	9.0	---	.7	5.0	14.7	525.3	---		355.3	881.9
Non-weeded check			5.3	9.7	1.3	5.3	21.6	150.0	392.3	28.3	410.7	981.3
Hand-weeded check			---	---	---	---	---	---	---	---	---	---

A = Grasses - Junglerice (*Echinochloa colonum*); goosegrass (*Eleusine indica*); red spangled top (*Leptochloa filiformis*); angle grass (*Pospolum panicutatum*); large crabgrass (*Digitaria sanguinalis*); B = Jimsonweed (*Datura stramonium*); C = Spiderflower (*Cleome spinosa*); D - Horse purslane (*Trianthema portulacostrum*).

2. Herbicide Evaluations in Pigeon Pea

Pigeon peas (*Cajanus cajan* (L.) Millsp.) is an increasingly important crop in Puerto Rico and other caribbean countries. In this crop as well as other tropical crops, weed competition is a major cause of yield losses.

To reduce these losses, it is necessary to identify and register selective herbicides which can be recommended to and used by pigeon pea growers.

Two trials were conducted one at Isabela and the other at the Fortuna substation. Each site differed in soil type, weed populations and amount of rainfall.

The purpose of these trials was to determine if herbicides which were found effective in soybeans could be effectively utilized in pigeon peas.

Kaki pigeon pea seeds were drilled in 60 cm rows at a rate of about 20 seeds per meter row on April 10th in Isabela. Treatments (Table 3) were arranged in a randomized complete block design with three replications. Plots were 2.4 m wide by 6.0 m long. Preemergence treatments were sprayed the following day of planting and postemergence treatments were applied two weeks later. Herbicides were delivered as previously described for soybean herbicide trials. The experimental area was irrigated the day after spraying preemergent herbicides, and afterwards as needed to maintain adequate soil moisture.

Predominant weeds in Isabela were southern sandbur (*Cenchrus echinatus*), junglerice (*Echinochloa colonum*), wood sorrell (*Oxalis intermedia*), wild poinsettia (*Euphorbia heterophylla*), and morning glory (*Ipomoea tiliacea*).

Handweeded check plots were hoed at 2, 4, and 6 weeks after planting. On the same dates herbicide injury and amount of weed control were estimated visually using a 0 to 10 and a 0 to 100 scale, respectively. At 4 weeks, weed samples were taken by throwing a 25 by 50 cm frame 3 times in each plot and collecting all the weeds within the frame. Weeds from each plot were placed in paper bags and taken to the laboratory for counting and weighing.

RESULTS AND DISCUSSION

Only oxyfluorfen caused severe toxicity after two weeks (Table 3). Other treatments caused only slight toxicity indicating their selectivity for pigeon peas.

At 4 weeks there was an slight increase in the toxicity ratings of the systemic herbicides metribuzin, prometryn, and cyanazine and a decrease in the ratings of the contact herbicides. Water infiltration appeared to favor the movement of the systemic herbicides and to increase their absorption by the crop. Moderate injury was found for oxyfluorfen at the higher rates (0.75 and 1.0 kg/ha) and plants in the plots treated with 0.5 kg/ha of oxyfluorfen exhibited slight injury. Post-emergence applications of acifluorofen caused complete crop destruction.

Phytotoxicity ratings taken at 6 weeks after planting indicated that pigeon peas recovered from the initial injury caused by all the preemergence treatments but oxyfluorfen at 1.0 kg/ha.

Table 3: Pigeon pea herbicide evaluation, Isabela 1980. Injury ratings and percent weed control at 2, 4 and 6 weeks after planting.

Herbicide Common Name	Rate kg/h	Time of application	Injury Ratings at week			% Total Weed Control at week		
			2	4	6	2	4	6
Metribuzin	0.5	PREEM	1.0	.2	0.0	57	53	32
Metribuzin	0.75	PREEM	1.3	2.8	1.7	53	22	13
Metribuzin	1.0	PREEM	.7	1.0	.7	60	50	45
Prometryn	1.0	PREEM	.7	.3	.3	63	30	22
Prometryn	2.0	PREEM	.3	1.3	1.3	58	42	23
Oxyfluorfen	0.5	PREEM	6.0	2.0	1.2	93	77	63
Oxyfluorfen	0.75	PREEM	7.6	4.7	1.3	95	90	80
Oxyfluorfen	1.0	PREEM	8.3	5.7	3.7	100	97	82
Oxadiazon	1.0	PREEM	1.0	.8	0.0	82	40	32
RP 20630	1.0	PREEM	.7	.7	0.0	87	77	58
RP 20810	0.75	PREEM	1.0	.5	.3	78	47	42
RP 20810	1.0	PREEM	1.3	1.7	.7	78	67	47
Cyanazine	1.5	PREEM	.3	1.7	1.0	53	18	13
Cyanazine	3.0	PREEM	1.6	1.7	1.0	67	40	23
Acifluorofen	1.0	POSTEM	---	10.0	10.0	---	23	18
Acifluorofen	2.0	POSTEM	---	10.0	10.0	---	30	20

Table 4. Pigeon pea herbicide evaluation - Isabela 1980.
Weed number and weed weight by species in .375 m^2 at 4 weeks after planting.

Herbicide	Weed Number						Weed Weight grams					
	A 1/	B	C	D	E	Total	A	B	C	D	E	Total
Metribuzin	33	132	2	3	4	174	97.3	50.4	2.6	15.6	13.9	179.8
Metribuzin	35	172	4	4	-	215	78.0	93.9	12.5	12.7	--	197.1
Metribuzin	25	68	1	3	2	99	48.1	29.3	2.1	17.6	2.2	99.3
Prometryn	31	96	4	1	5	137	107.9	66.6	10.4	4.0	10.8	199.7
Prometryn	33	143	7	0	3	186	109.9	67.7	40.8	0.0	11.6	230.0
Oxyfluorfen	8	--	1	4	6	19	12.2	0.0	0.7	26.7	9.2	48.8
Oxyfluorfen	4	3	1	3	5	16	11.1	1.4	0.7	11.2	10.5	34.9
Oxadiazon	0	0	0	0	10	10	0.0	0.0	0.0	0.0	13.0	13.0
Oxadiazon	8	3	3	2	10	26	30.0	1.5	20.4	20.5	66.5	138.9
RP 20630	1	0	0	8	7	15	1.4	0.0	0.0	81.6	36.2	119.2
RP 20810	10	35	2	4	12	63	24.0	16.0	8.1	6.5	31.5	86.1
RP 20810	9	56	4	2	5	76	20.2	26.7	18.8	9.1	15.0	89.8
Cyanazine	31	169	2	2	4	208	84.9	82.3	3.9	14.1	31.1	216.3
Cyanazine	11	154	1	2	2	168	46.2	78.3	7.4	1.7	19.5	153.1
Acifluorofen	30	48	2	0	5	85	86.8	22.5	2.9	0.0	15.7	127.9
Acifluorofen	32	29	0	0	3	64	77.7	8.1	0.0	0.0	11.1	96.9
Unweeded	39	209	3	3	4	258	104.4	114.5	17.8	23.0	5.1	264.8

1/ A = Grasses (*Cenchrus echinatus*, *Echinochloa colonum*)
B = Woodsorrel (*Oxalis intermedia*)
C = Wild poinsettia (*Euphorbia heterophylla*)
D = Morningglory (*Ipomoea tiliacea*)
E = Others (Sicklepod = *Cassia obtusifolia*; railway daisy = *Bidens pilosa*).

Excellent to complete weed control was given at 2 weeks by all rates of oxyfluorfen (Table 3). Satisfactory to good weed control was observed in plots treated with RP 20630, oxadiazon, and RP 20810. The degree of weed control afforded by the other treatments was less than satisfactory.

At 4 weeks, plots treated with 0.75 or 1.0 kg/ha of oxyfluorfen showed excellent weed control. Satisfactory weed control was obtained with oxyfluorfen 0.5, and RP 20630 1.0. At 6 weeks, only the plots treated with oxyfluorfen showed from moderate to good weed control.

The results of this trial indicate that oxyfluorfen at low rates deserve further testing.

The numbers and weights of weeds present at 4 weeks were similar to visual estimates of weed control (Table 4). Southern sandbur was not satisfactorily controlled by metribuzin, prometryn, cyanazine and acifluorfen. Wood sorrell escaped the action of metribuzin, prometryn, and cyanazine. Prometryn and oxadiazon and RP 20810 did not control wild poinsettia. The highest number and weight of morning glory was registered in plots treated with RP 20630. Treatments which appreciably reduced numbers and weights of this weed were prometryn at both rates and oxyfluorfen 1.0, cyanazine 3.0, and both rates of acifluorfen.

Another herbicide trial was conducted in Fortuna. The trial was conducted using the same techniques as described earlier for Isabela. This trial was planted June 24th. Treatments included were somewhat different than the Isabela trial (Table 4).

Predominant weeds in the experimental area were jungle rice (*Echinochloa colonum*), red spangled top (*Leptochloa filiformis*), jimson weed (*Datura stramonium*), spider flower (*Cleome spinosa* and *C. gynandra*) and horse purslane (*Trianthema portulacastrum*).

RESULTS AND DISCUSSION

Most preemergence and preplant incorporated treatments caused slight to moderate injury to pigeon peas but the effect was not lasting (Table 5). Higher injury ratings at 2 weeks were registered in plots treated with metribuzin 1.0, cyanazine plus alachlor (2.0 + 1.0), metribuzin 0.75, metribuzin plus vernolate (0.5 + 3.0), metribuzin 0.5, and metribuzin plus trifluralin (0.5 + 1.0). Of these treatments only metribuzin 1.0 gave high toxicity ratings at 4 weeks after planting. MO 70077 was highly toxic to pigeon pea at the rates of 1.0 and 2.0 kg/ha.

Prometryn 2.0, metribuzin 0.75, metribuzin 0.5 and 1.0, cyanazine plus alachlor (2.0 + 1.0) and metribuzin plus trifluralin (0.5 + 1.0) gave over 90% weed control at 2 weeks (Table 5). Good control (81 to 90%) was given by oxadiazon 1.5, prometryn plus metolachlor (0.5 + 1.0), cyanazine 2.0 and cyanazine plus alachlor (1.0 + 1.0). Satisfactory control (71 to 80%) was provided by alachlor 1.5 and prometryn 1.0.

At 4 weeks from planting excellent control was observed in plots treated with prometryn 2.0 and with oxadiazon 1.5, and good control was found for all rates

Table 5. Pigeon pea herbicide evaluation - Fortuna 1980. Injury ratings and percent weed control.

Herbicide	Rate kg/ha	Time of Application	Injury Rating at week 2	Injury Rating at week 4	% Weed Control at week 2	% Weed Control at week 4	Yield kg/h
Oryzalin	1.0	PREEM	1.3	.3	57	53	4.796
Oryzalin	2.0	PREEM	1.7	.3	58	63	3.616
Oxadiazon	0.75	PREEM	1.3	1.0	68	50	4.713
Oxadiazon	1.5	PREEM	2.0	0.0	90	92	4.861
Metribuzin	0.5	PREEM	3.0	1.0	92	90	4.102
Metribuzin	0.75	PREEM	4.0	1.3	97	87	5.977
Metribuzin	1.0	PREEM	6.3	4.7	92	87	3.537
Prometryn	1.0	PREEM	1.7	.3	73	65	4.463
Prometryn	2.0	PREEM	2.3	1.0	98	95	4.945
Alachlor	1.5	PREEM	1.7	0.0	75	47	4.903
Metolachlor	1.5	PREEM	1.0	0.0	63	50	4.648
Cyanazine	2.0	PREEM	2.3	1.0	85	85	3.852
Metribuzin / Metolachlor	0.5 / 1.0	PREEM	2.3	.3	87	82	5.091
Prometryn / Metolachlor	1.0 / 1.0	PREEM	2.3	.3	90	70	4.461
Cyanazine / Alachlor	1.0 / 1.0	PREEM	2.3	.3	83	67	5.375
Cyanazine / Alachlor	2.0 / 1.0	PREEM	4.7	1.0	92	77	4.246
Vernolate	3.0	PPI	1.0	1.3	60	53	3.912
Trifluralin	1.5	PPI	.7	.3	48	50	3.532
Metribuzin / Vernolate	0.5 / 3.0	PPI	3.3	1.3	88	72	3.829
Metribuzin / Trifluralin	0.5 / 1.0	PPI	2.7	.7	92	82	3.681
Profluralin	1.0	PPI					
Bentazon	1.5	POST	.7	1.7	42	67	4.227
Bentazon	1.5	POST	---	.3	25	10	
MO 70077	0.75	POST	---	2.7	---	33	3.111
MO 70077	1.0	POST	---	6.0	---	40	4.356
MO 70077	2.0	POST	---	7.0	---	63	3.218
Unweeded check							3.829
Hand-weeded check							5.805

Table 6: Pigeon pea herbicide evaluation. Fortuna 1980. Weed number and weed weight in .375 m^2 4 weeks after planting.

Herbicide	Rate kg/h	A	B	C	D	E	Total	A	B	C	D	E	Total
Oryzalin	1.0	0	15	5	1	1	22	0	374	102	24	26	526
Oryzalin	2.0	0	16	0	1	0	17	0	591	0	86	0	677
Oxadiazon	0.75	1	7	3	3	0	14	2	243	90	65	0	400
Oxadiazon	1.5	1	2	1	2	0	6	5	63	27	86	0	181
Metribuzin	0.5	2	1	1	1	1	6	29	10	222	24	9	294
Metribuzin	0.75	1	2	3	6	3	15	6	16	123	196	13	354
Metribuzin	1.0	0	0	3	1	0	4	0	0	168	11	0	179
Prometryn	1.0	4	5	7	2	3	21	26	182	267	94	39	608
Prometryn	2.0	4	1	1	2	1	9	42	39	36	34	5	156
Alachlor	1.5	2	10	3	4	0	19	8	340	145	115	0	608
Metolachlor	1.5	0	21	5	5	0	31	0	395	100	103	0	598
Cyanazine	2.0	3	4	0	2	4	13	53	112	0	43	27	235
Metribuzin / Metolachlor	0.5 / 1.0	2	2	4	1	3	12	27	67	247	5	86	432
Prometryn / Metolachlor	1.0 / 1.0	1	1	3	1	1	6	23	93	215	10	12	353
Cyanazine / Alachlor	1.0 / 1.0	3	7	0	5	0	15	23	219	0	98	0	340
Cyanazine / Alachlor	2.0 / 1.0	2	4	0	1	0	7	8	116	0	207	0	331
Vernolate	3.0	1	14	0	3	0	18	33	425	0	256	0	714
Trifluralin	1.5	0	7	5	13	0	25	0	362	104	493	0	959
Metribuzin / Vernolate	0.5 / 3.0	2	4	6	1	0	13	29	144	287	163	0	623
Metribuzin / Trifluralin	0.5 / 1.0	1	2	3	1	0	7	5	58	191	34		288
Profluralin / Bentazon	1.0 / 1.5	1	9	3	5	1	19	14	131	44	76	5	270
Bentazon	1.5	3	0	1	12	2	18	40	0	7	415	87	549
MO 70077	0.75	7	2	5	6	1	21	133	19	97	227	6	482
MO 70077	1.0	16	0	1	3	0	20	191	0	16	67	0	274
MO 70077	2.0	6	0	0	3	2	11	75	0	0	61	9	145
Unweeded check		3	4	2	7	2	18	72	152	42	375	151	792

A = Grasses (Junglerice = *Echinochloa colonum*; red spangled top - *Leptochloa filiformis*). B - Jimsonweed (*Datura stramonium*), C = Spiderflower (*Cleome spinosa* and *gynandra*). D - Horse purslane (*Trianthema portulacastrum*). E = Other broadleaf weeds.

of metribuzin, cyanazine at 2.0, and metribuzin plus trifluralin (0.5 + 1.0). Satisfactory control at 4 weeks was observed in plots treated with cyanazine plus alachlor (2.0 + 1.0), metribuzin plus vernolate (0.5 + 3.0), and prometryn plus metolachlor (1.0 + 1.0). The rest of the treatments gave less than satisfactory control.

Treatment yields in decreasing order were: metribuzin 0.75, handweeding, cyanazine plus alachlor (1.0 + 1.0), metribuzin plus metolachlor (0.5 + 1.0), prometryn 2.0, alachlor 1.5, oxadiazon 1.5, oryzalin 1.0, oxadiazon 0.75, and metolachlor 1.5 (Table 5).

Oryzalin, alachlor, metolachlor and trifluralin at all rates used controlled grasses but not some of the common broadleaved weeds. The numbers and weights of weeds for each treatment are presented in Table 6.

Oxadiazon at 1.5 and prometryn at 2.0 gave good control of a broad spectrum of weeds present.

Metribuzin did not control spider flower. Cyanazine controlled spider flower effectively but was not particularly effective for grasses. Vernolate controlled both grasses and spider flower.

MC 70077 at 1.0 controlled broadleaved weeds effectively. The effect of bentazon on the different weeds species needs further observation. Results were different when it was applied alone compared to when it followed a preplant incorporated application of profluralin.

3. Weed Competition Studies

Soybean cultivars Jupiter and Williams were planted in Isabela on June 26, 1979, October 20, 1979, April 9, 1980 and July 21, 1980. Three populations were obtained by planting in rows 30, 45, and 60 cm apart at a distance of 10 cm between plants in the row. The populations were 33.3, 22.2, and 16.6 plants per m^2.

The purpose of the trials was to determine the effect of plant population, planting date, and variety, on the critical period of weed competition and on weed development. For this reason 5 weeding schedules were included as subtreatments. These were: weeding starting at 2, 3, 4, and 5 weeks after soybean emergence and maintaining plots weed free throughout, and a nonweeded control.

Soybean seed was drill planted with application of *Rhizobium japonicum* at a rate of 0.5 g per m row. Triple superphosphate was applied as a band at a rate of 100 kg/ha. Experimental fields were irrigated by sprinklers immediately following application of superphosphate.

Treatments were replicated 3 times and arranged in a split-plot design. Varieties occupied the main plots and distances and weeding schedules the subplots. Subplots were 3.6 m by 5.0 m. This was equivalent to 12 rows of 30 cm, 8 rows of 45 cm and 6 rows of 60 cm.

Six, four, and three center rows were harvested for the 30, 45, and 60 cm row spacings, respectively.

Weed samples were collected from the plots that were nonweeded by throwing a frame as previously described for the herbicide trials. Samples were counted and weighed in the laboratory.

Soybean height was measured weekly. Plant development was registered using the stages of plant development described by Fehr et. al. When plants were at harvest stage 10 plants were collected to determine number of pods per plant.

RESULTS AND DISCUSSION

Earlier plantings caused later flowering, late maturity, and first flower appearance when plants were taller and a greater number of nodes (Table 7). Plants of earlier plantings were taller at maturity and produced more nodes than those of later plantings.

Cultivar Williams developed faster than Jupiter. Plants in unweeded plots had a slight tendency to keep their leaves longer (delayed maturity): otherwise, weeding schedules did not appear to affect plant maturity.

The main broadleaved weeds present in the June 1979 and April 1980 plantings were: wild poinsettia (*Euphorbia heterophylla*), wood sorrell (*Oxalis intermedia*), and morning glory (*Ipomoea* sp.). Braodleaved weeds in the October 1979 and July 1980 plantings were: wild poinsettia, pigweed (*Amaranthus dubius*), mugwort (*Parthenium hysterophorus*), purslane (*Portulac oleracea*), spanish needles (*Bidens pilosa*), wood sorrell and morning glory. Primary grasses present during the experiment were jungle rice (*Echinochloa colonum*) and goose grass (*Eleusine indica*).

The weights of weeds per meter registered from the third to sixth weeks are shown in Table 8. Significantly higher weed weights were registered in the April 1980 planting when rainfall was heaviest. There was more weed growth associated with plots planted to Jupiter than Williams. Nevertheless this difference was not statistically significant. As row spacing increased from 30 to 60 cm, weed weight per area also increased. Weed weights were significantly higher at 60 than 30 cm row spacings.

For the June 1979 planting yield of Williams was significantly greater than that of Jupiter for all three plant populations (Table 9). Among the row spacings no significant differences were found. Yield was not different for plots which were weeded throughout the experiment and those weeded starting after the second, third, and four weeks. When weeding was delayed until the fifth week yield was markedly reduced. This suggests that weed competition during the 4th week of growth was critical in lowering yield potential. This effect was more pronounced for Williams than for Jupiter. The lowest yields were obtained in the nonweeded control. No differences were found among distances and varieties.

Higher yield of Williams was associated with a larger number of plants at harvest. The number of pods per plant was lower for Williams compared to Jupiter. The general tendency was the increased number of pods at the lower plant populations. In Jupiter the increase in the number of pods per plant did not compensate for the low population.

Yields for the October 1979 planting were much lower than those of the June planting (Table 10). Plants developed faster and had a much shorter growth period. Yield of both cultivars was highest at the 30 and 45 cm spacings and there were no differences between cultivars. Jupiter tended to yield better than the wider row spacing and Williams at the narrower ones. Delaying the first weeding up to the end of the fifth week did not reduce significantly the yields of Jupiter. In Williams the five week delay of weeding significantly reduced yield. This suggests that in earlier varieties the critical period of competition will occur earlier. This effect was most obvious at 30 and 45 cm row spacings and not at 60 cm.

Number of pods per plant for Jupiter was lower in the October 1979 planting than in that of June. This appeared partly due to a higher harvest population and in part to shorter period of growth.

The effect of delaying weeding until the fifth week did not affect yield as much as it did in the earlier planting. Full season weed competition caused considerable loss but less than that found in June plantings.

Decreased yield seemed related to lower numbers of harvested plants and lower numbers of pods per plant.

The April 1980 planting resulted in larger plants for both cultivars (Table 7). These plants required more time to flower and produced more nodes at maturity. Weights of weeds was greater than that at other plantings (Table 8). Yield of Williams was significantly higher than that of Jupiter (Table 11). Yields tended to be greater at the 45 and 30 cm spacings than for the 60 cm spacing. This difference, however, was not statistically significant. Harvest populations were associated with yield and Jupiter had a lower plant population than Williams. Increased numbers of pods per plant at 60 cm was not sufficient to compensate for reduced plant numbers. Yield per plant was half or less of that of the June planting. Conditions which favored vigorous vegetative growth were also associated with extremely late flowering especially in Jupiter and a decreased number of flowers and pods set. It also appeared that numbers of seed per pod were reduced in this planting.

Although yield of Jupiter was not affected by the time of first weeding, delaying weeding to the 3rd week significantly reduced yield of Williams. Delaying weeding in Williams to the 4th or 5th weeks caused further significant losses in yield.

In the July 1980 planting, yields of Jupiter and Williams were not statistically different. Yield of both cultivars tended to be higher at 30 and 45 cm row spacing than that of 60 cm. Delaying the first weeding to the 4th week after emergence of the crop caused a marked reduction of yield especially in Williams. Lowest yields were found in nonweeded plots of Williams at 60 cm. Without weeding higher yields were registered at 45 cm. The highest yield was found in narrow rows with early weeding.

At this date harvest population of Williams was lower than that of other plantings. This probably resulted in the low yields found. Populations of Jupiter and yield were similar to those of previous plantings.

Table 7: Effect of time of planting on development of 2 soybean cultivars

Planting Date	Cultivar	Emergence to flower			Emergence to maturity			Yield
		Days	Nodes	Height (cm)	Days	Nodes	Height (cm)	Tons/h.
June 26	Williams	34	7	20	112	9	53	1.82 a[w/]
	Jupiter	46	10	47	146	10	72	1.24 b
Oct. 2	Williams	25	4	15	89	8	37	1.21 a
	Jupiter	32	6	22	107	8	43	1.05 a
Apr. 9	Williams	42	8	43	104	10	62	2.32 a
	Jupiter	67	12	91	180	12	92	0.96 b
July 21	Williams	28	4	18	92	9	47	1.15 a
	Jupiter	35	7	25	117	9	50	1.71 a

w/ Means followed by a common lower case letter at the same planting date are not statistically different at P = 0.05 using FLSD.

Table 8: Effect of planting dates, varieties and row distances of soybeans on weed growth.

Dates of planting	Varieties	Row Distances 30 cm.	45 cm.	60 cm.	Planting date means
		Weed fresh weight gr/m^2 [2/]			
June 26	Jupiter	624.3	549.7	897.7	
	Williams	556.9	512.9	743.9	
Row distance means		590.7	531.3	820.8	647.6 [b/]
Oct. 20	Jupiter	427.3	618.6	554.3	
	Williams	403.8	460.5	623.4	
Row distance means		415.5	539.5	588.8	514.6 [b/]
Apr. 9	Jupiter	973.1	1398.6	1530.7	
	Williams	739.4	1130.7	1170.7	
Row distance means		856.3	1264.7	1350.7	1157.2 [a/]
July 21	Jupiter	436.1	438.2	603.5	
	Williams	547.3	193.2	466.1	
Row distance means		491.7	315.7	534.8	447.4
					Cultivar Means
	Jupiter	615.2	751.3	896.5	754.3
	Williams	561.9	574.3	751.0	629.1
Row distance means		588.6	662.8	823.8	

Table 9: Yield and yield components of 2 soybean cultivars, planted on June 26, 1979 at 3 row distances and weeded at different times after plant emergence.

Weed of first weeding	Jupiter				Williams			
	Row Distances cm.							
	30	45	60	Weeding means	30	45	60	Weeding means
				Yield Tons/h.				
2	1.35	1.68	1.34	1.46[a]	2.01	1.81	2.12	1.98[a]
3	1.46	1.39	1.34	1.40[a]	2.02	2.10	2.05	2.06[a]
4	1.13	1.48	1.48	1.36[ab]	2.11	1.84	1.92	1.96[a]
5	1.11	1.48	1.20	1.26[b]	1.36	1.13	1.35	1.28[b]
Unweeded	.78	.87	.51	.72[c]	.85	1.10	.54	.83[c]
Row distance means	1.17[b]	1.38[ab]	1.17[b]	1.24	1.67[a]	1.60[a]	1.60[a]	1.62
				Plants Harvested/m^2				
2	35	26	21	27.3	49	43	37	43.0
3	40	28	20	29.3	40	34	28	34.0
4	30	26	16	24.0	37	38	36	37.0
5	37	24	16	25.6	54	38	25	39.0
Unweeded	26	27	12	21.7	37	36	21	31.3
Row distance means	33.6	26.2	17.0	25.6	43.4	37.8	29.4	36.0
				Number of Pods per Plant				
2	35	44	53	44.0	13	17	22	17.3
3	42	39	55	45.3	15	19	21	18.3
4	41	39	39	39.7	15	18	17	16.7
5	36	40	40	38.7	10	12	17	13.0
Unweeded	40	29	41	36.6	8	13	10	10.3
Row distance means	38.8	38.2	45.6	40.9	12.2	15.8	17.4	15.1

Table 10: Yield and yield components of 2 soybean cultivars planted on October 20, 1979 at 3 row distances and weeded at different times after plant emergence.

Weed of first weeding	Jupiter				Williams			
	Row Distances cm.							
	30	45	60	Weeding means	30	45	60	Weeding means
	Yield Tons/h.							
2	1.44	1.17	1.10	1.24[a]	1.50	1.48	.85	1.28[ab]
3	1.07	1.18	1.02	1.09[a]	1.78	1.60	.72	1.37[a]
4	1.46	1.09	.96	1.17[a]	1.68	1.76	.64	1.36[a]
5	1.31	1.18	.90	1.13[a]	1.08	1.66	.53	1.09[bc]
Unweeded	.57	.59	.72	.63[b]	1.14	.99	.57	.90[c]
Row distance means	1.17[ab]	1.04[b]	.94[bc]	1.05	1.44[a]	1.50[a]	.66[c]	1.02
	Plants Harvested/m^2							
2	49	43	38	43.3	36	26	18	26.7
3	40	34	28	34.0	34	27	13	24.7
4	37	38	36	37.0	34	27	16	25.7
5	54	37	25	38.7	27	26	16	23.0
Unweeded	35	36	20	30.3	31	26	14	23.7
Row distance means	43	37.6	29.4	36.7	32.4	26.4	15.4	24.8
	Number of Pods per Plant							
2	33	23	19	25.0	20	19	23	20.7
3	36	24	18	26.0	17	19	18	18.0
4	26	23	14	21.0	19	19	16	18.0
5	33	20	14	22.3	17	18	15	16.7
Unweeded	22	31	9	20.7	18	19	19	18.7
Row distance means	30.0	24.2	14.8	23.0	18.2	19.0	18.2	18.5

Table 11: Yield and yield components of 2 soybean cultivars planted on April 9, 1980 in 3 row distances and weeded at different times after plant emergence.

	Jupiter				Williams			
	Row Distances cm.							
Weed of first weeding	30	45	60	Weeding means	30	45	60	Weeding means
				Yield Tons/h.				
2	1.07	1.12	.89	1.03[a]	2.77	3.11	2.48	2.79[a]
3	1.10	1.25	.80	1.05[a]	2.64	2.82	2.37	2.61[ab]
4	.99	.91	.81	.90[ab]	2.66	2.39	2.28	2.44[b]
5	1.32	.98	1.28	1.19[a]	2.38	2.30	1.67	2.11[c]
Unweeded	.68	.46	.74	.63[b]	1.69	1.67	1.24	1.53[d]
Row distance means	1.03[a]	.94[a]	.91[a]	.96	2.50[a]	2.46[a]	2.01[a]	
				Plants Harvested/m^2				
2	21	18	16	18.3	58	41	31	43.3
3	17	20	15	17.3	52	42	31	41.7
4	23	18	18	19.7	49	39	34	40.7
5	19	14	14	15.7	58	38	30	42.0
Unweeded	22	19	15	18.7	52	52	34	46.0
Row distance means	20.4	17.8	15.6	17.9	53.8	42.4	32.0	42.7
				Number of Pods per Plant				
2	33	37	45	38.0	15	21	26	20.7
3	40	39	41	38.3	19	15	23	19.0
4	29	48	50	40.0	17	15	16	16.0
5	43	26	39	42.3	14	13	11	12.7
Unweeded	38	38	37	36.0	20	22	25	22.3
Row distance means	36.6	37.6	42.4	38.9	17.0	17.2	20.2	18.1

Table 12: Yield and yield components of 2 soybean cultivars planted on July 21, 1980 in 3 row distances and weeded at different times after plant emergence.

	Jupiter				Williams			
	Row Distances cm.							
Weed of first weeding	30	45	60	Weeding means	30	45	60	Weeding means
				Yield Tons/h.				
2	2.19	1.77	1.87	1.94^{a}_{ab}	1.68	1.65	1.05	1.46^{a}
3	2.00	1.83	1.64	1.82_{c}	1.73	1.40	1.45	1.53^{a}
4	1.66	1.82	1.44	1.64_{bc}	.81	1.09	.61	$.84^{c}$
5	1.72	1.82	1.61	1.72_{d}	.96	1.26	.99	1.07^{b}
Unweeded	1.41	1.46	1.37	1.41	.88	1.39	.36	$.88^{c}$
Row distance means	1.80^{a}	1.74^{a}	1.59^{a}		1.21	1.36	.89	
				Plants Harvested/m				
2	26	15	13	18.0	18	16	10	14.7
3	21	14	13	16.0	18	15	11	14.7
4	20	16	11	15.7	14	16	8	12.7
5	19	19	13	17.0	13	15	11	13.0
Unweeded	19	15	14	16.0	19	13	9	13.7
Row distance means	21.0	15.8	12.8	16.5	16.4	15.0	9.8	13.7
				Number of Pods per Plant				
2	51	33	58	47.3	38	36	39	37.7
3	43	52	61	52.0	28	30	42	33.3
4	48	53	54	51.7	27	32	26	28.3
5	40	48	57	48.3	28	30	34	30.7
Unweeded	39	42	47	42.7	20	27	39	28.7
Row distance means	44.2	45.6	55.4	48.4	28.2	31.0	36.0	31.7

A compensatory increase of pods per plant was noted in this planting especially at the low population (60 cm). Pod number per plant decreased as first weeding was delayed especially in the narrow row spacings.

These trials indicated higher potential yields for earlier plantings. Humid long day conditions favored increased crop and weed growth. Under these conditions weed competition and related yield losses were greater than under dry and short day conditions. Cultivars with greatly reduced vegetative development like Williams appear to be favored at closer spacing and higher plant populations than those optimum [illegible] varieties like Jupiter which are considerable larger and have greater vegetative development. In these trials stability of yield was greatest at 4[illegible] cm than at 60 or 30 cm distances for both cultivars. Critical period of weed competition was generally earlier for Williams than Jupiter. However, when Jupiter's vegetative development was greatly curtailed, critical period for the two cultivars coincided. In Williams but not Jupiter weed loss was reduced at higher plant density.

b. WEED SCIENCE AND PATHOLOGY (Paul Hepperly in cooperation with G. Riveros and J. Mignucci, respectively)

1. Factors Affecting Metribuzin Selectivity in Soybeans and Other Grain Legumes

Herbicide selectivity is a concept used to describe the differential response of crop plants and target weeds to herbicides. Ideally the herbicide will inhibit a broadspectrum of important weeds without damaging selected crop plants. Some herbicides are marginally selective, i.e. they give effective control of prevalent weeds but also cause some damage to the crop. In soybeans metribuzin is an example of a marginally selective herbicide. Although it is one of the more effective broadspectrum herbicides it is often associated with phytotoxicity. Some cultivars such as Tracy are extremely sensitive to metribuzin. This cultivar is also resistant to all known races of *Phytophthora megasperma* on soybean. Although resistant plants can be selected from populations of Tracy, these plants are also increased in susceptibility to *Phytophthora*. Genes for *Phytophthora* susceptibility and metribuzin resistance appeared linked in this cultivar.

Metribuzin is a member of the triazine group of herbicides. These are the most widely used herbicides throughout the world. Triazine selectivity depends not only the ability of plants to detoxify them but also on placement practices which lessen triazine to plant contact. Critical steps in the toxic action of herbicides are: i) contact of the herbicide with the plant; ii) penetration of the plant surface by the herbicide; iii) translocation of the herbicide to the site of action; and iv) disruption of plant processes to cause death. Triazines primarily affect plant photosynthesis and must be translocated to the leaves. These herbicides move through the xylem and accumulate in the leaf margins.

The most effective selectivity reactions are those resulting in detoxification. Corn detoxifies triazine by binding it to glutathione. Glutathione conjugation is a detoxification method found in plants and animals alike. Once conjugated triazines are broken down into benign substances. In sandy soils and at shallow depths of planting, herbicide contact with the crop is increased and increased

phytotoxicity may result.

Since metribuzin is a very effective broadspectrum herbicide of marginal selectivity for soybeans, studies were conducted to increase knowledge of the factors affecting metribuzin selectivity. These tests included: i) cotyledon absorption and translocation of metribuzin; ii) selectivity associated with hypogeal and epigeal grain legumes; and iii) effects of soybean seed quality in metribuzin selectivity.

COTYLEDON ABSORPTION OF METRIBUZIN

Ten cm pots were filled with loam potting soil and five pink bean seeds were planted. After 1 week the strongest seedling in each pot was selected and the others roughed. Solutions of i) water or ii) 10 ppm or iii) 100 ppm metribuzin were prepared and cotton wicks were used to connect the solutions with seedling cotyledons. Each test solution (Treatment) was replicated four times. Every other day plants were checked for herbicide symptoms and leaf area with chlorosis or necrosis was estimated. At 32 days plants were harvested and yield was taken, fresh and dry weights.

Foliar symptoms of metribuzin damage were evident after 3 days when cotyledons were connected to the 100 ppm solution (Table 13). Damage increased till all foliage was damaged after 11 days. At 10 ppm damage became visible after 11 days and foliage was 80% damaged after 25 days. No control plants showed herbicide injury. Dosages of 10 ppm and 100 ppm metribuzin reduced fresh and dry weights of 35-day-old plants.

Table 13: Development of herbicide damage by absorption of 3 metribuzin dosages through the cotyledons.

Metribuzin Conc.	3	5	7	9	11	13	15	17	79	25	Plant[c/] Weight (g) Fresh	Dry
0	0	0	0	0	0	0	0	0	0	0	8.40	1.40
10	0	0	0	0	17	27	37	60	73	81	4.30	0.90
100	20	43	65	93	100	100	100	100	100	100	0.30	0.26

a/ Concentration of aqueous solution lead to cotyledon by cotton wicks.
b/ Based on 4 replications.
c/ Visual estimate.
d/ Weights from plants harvested at 32 days.

Triazine herbicides applied to soil are thought to be absorbed through plant roots. Cotyledons during early seedling stages can be active sites of absorption and translocation.

METRIBUZIN TOXICITY IN EPIGEAL AND HYPOGEAL GRAIN LEGUMES

White beans, pink beans, cowpeas, and soybean varieties Improved Pelican and Jupiter with epigeal emergence were compared with pigeon pea (2B-Bushy), peas, lentils, chick peas and scarlet runner beans with hypogeal emergence for their reactions to metribuzin. Six seeds of each species or variety were planted in six 10 cm pots in loam potting soil. Half of the pots were treated with 0.75 kg ai metribuzin per hectare and the other was left nontreated. After 3 weeks, plants were rated for percentage of foliage with metribuzin damage and plants were harvested and height, fresh weight, and dry weights were determined.

All epigeal grain legumes tested showed significant damage to metribuzin (Table 14); however, of those legumes with hypogeal emergence only scarlet runner beans showed foliar symptoms. When metribuzin was applied, height was significantly reduced in all epigeal legumes with exception of Improved Pelican soybean. Lentils was the only hypogeal grain legume showing height reduction. Fresh weight and dry weights showed that more epigeal grain legumes were significantly inhibited by metribuzin. Treatment difference were more obvious using dry weight data. Hypogeal legumes showed a dry weight reduction only in the case of lentils.

Hypogeal emergence appeared associated with reduced phytotoxicity from metribuzin. Four of five hypogeal legumes showed considerably less damage from metribuzin than soybeans which as the least damaged legume of epigeal emergence.

METRIBUZIN TOXICITY TO GRAIN LEGUMES IN SALT SOLUTIONS

To eliminate positional effects between hypogeal and epigeal legumes, each was tested by submerging their roots in salt solutions with either 0, 10, or 100 ppm of metribuzin. Seeds were first germinated 7 days on cellulose pads until roots emerged from the germination trays. Trays were then placed over pans filled with salt solutions and salt solutions with metribuzin. Each legume or variety at each concentration was replicated six times with a single seedling representing an experimental unit. After 10 and 20 days, foliar damage was rated and after 20 days plant fresh and dry weights were determined.

In all legumes tested damage increased with time of exposure and concentration (Tables 15 and 16). Hypogeal legumes showed less damage than epigeal legumes. This evident by their small change in plant yield with the presence of metribuzin.

It appears that the hypogeal group of grain legumes has some resistance to metribuzin compared to epigeal grain legumes.

The difference of hypogeal and epigeal grain legumes in regard to selectivity cannot be explained solely by positional effects and the absorption of herbicide by cotyledons during emergence.

EFFECT OF SOYBEAN SEED QUALITY ON METRIBUZIN SELECTIVITY

Several workers have suggested that soybean seed quality can influence selectivity towards metribuzin. This has been used as a possible explanation of year-to-year changes in the reactions of the same variety's reaction to metribuzin. In our experiments, Jupiter (generally a variety of poor seed quality)

Table 14: Metribuzin damage, plant height, and fresh and dry weights of epigeal and hypogeal grain legumes with or without application of metribuzin to soil surface.

	Epigeal Emergence					Hypogeal Emergence				
				Soybeans						
Treatment	Cowpea	White Beans	Pink Beans	Improved Pelican	Jupiter	Pigeon Pea	Peas	Lentils	Chick peas	Scarlet prunner beans
Damage										
Nontreated (NT)	0[a/]	0	0	0	0	0	0	0	0	0
	**[b/]	**	**	**	**	NS	NS	NS	NS	*
Metribuzin (MT) (0.75 kg/ha)	91.8	85.8	80.2	3.5	19.2	0.0	0.0		0.0	7.5
Height										
NT	23.9	29.1	29.8	36.7	34.8	16.6	19.7	20.8	28.0	20.1
	*	**	*	NS	*	NS	NS	**	NS	NS
MT	14.5	16.7	21.7	34.7	28.6	16.1	18.0	12.0	24.6	19.8
Fresh weight										
NT	2.48	2.88	2.97	1.40	2.76	0.91	1.15	0.34	3.03	4.05
	**	**	NS	NS	NS	NS	NS	**	NS	*
MT	.78	.76	2.46	1.40	2.52	1.27	1.33	0.20	2.71	3.47
Dry Weight										
NT	.250	0.35	0.57	0.24	0.38	0.18	0.15	.093	.38	0.63
	**	**	**	**	*	NS	NS	**	NS	NS
MT	.086	0.35	0.34	0.17	0.28	0.19	0.14	.053	.36	0.52

a/ Based on 3 replications of 6 plants each.
b/ * = sig. P=0.05; ** sig. P=0.01, and NS = nonsig. based on non-paired t = test.

Table 15: Herbicide damage and plant yield of epigeal and hypogeal legume seedlings grown with roots submerged in 0, 10 or 100 ppm metribuzin.

Type of emergence	Metribuzin in solution	Foliar Damage					
		10 days			20 days		
		0	10	100	0	10	100
Epigeal[a]		0.0[b]	35.8	68.3	0.0	96.0	100.0
Hypogeal[a]		0.0	6.3	13.0	0.0	57.4	90.0

Type of emergence	Metribuzin in solution	Plant Yield					
		Fresh Weight			Dry Weight		
		0	10	100	0	10	100
Epigeal		3.09	0.97	0.69	0.41	0.21	0.12
Hypogeal		1.95	1.27	1.41	0.22	0.17	0.22

a/ Epigeal = cowpea, pink beans, white beans, and 'Improved Pelican' and 'Jupiter' soybeans.
Hypogeal = pigeon pea, peas, chickpeas, lentils, and scarlet runner beans.

b/ Each mean based on 6-replications for each of the 5 legumes tested.

Table 16: Metribuzin damage in various legumes with their roots in salt solution plus 0, 10 or 100 ppm metribuzin.

Legume/ dose	Damage at 10 days			Damage at 20 days			Plant Fresh Weight			Plant Dry Weight		
	0	10	100	0	10	100	0	10	100	0	10	100
Soybean Improved Pelican	0	45	52.0	0	00	100	1.88	2.10	0.82	.19	0.90	.18
Soybean Jupiter	0	24	34	0	80	100	2.52	1.42	1.20	.76	.10	.12
White Beans	0	20	84.0	0	100	100	1.98	0.11	0.11	1.50	.020	.050
Pink Beans	0	20	43.0	0	100	100	7.50	2.00	2.00	.85	.18	.22
Cowpea	0	60	80	0	100	100	1.56	0.20	0.30	.12	.03	.04
Pigeon Pea	0	20	15	0	35	88.0	0.95	0.73	0.55	.13	.090	.10
Peas	0	8	10	0	22	92.0	2.16	0.52	0.78	.21	.07	.10
Lentils	0	3	30	0	100	100	0.50	0.16	0.13	.03	.01	0.40
Chick peas	0	0	0	0	65	87.0	1.60	2.80	2.40	.27	.32	.36
Scarlet runner beans	0	0	10	0	65	80	4.86	2.15	3.20	4.40	.400	.52

a/ All beans based on six replications of one-plant each.

showed greater metribuzin damage in soil tests than Improved Pelican (a variety with fairly good seed quality). If seeds were first germinated and then placed in salt solutions plus metribuzin results were reversed. To test if poor seed quality increases damage of soybean by metribuzin, Improved Pelican seeds were accelerated aged by placement at 40°C and 90% RH for either 0, 1, 2, or 4 days. Seeds were then planted in soil which was either treated with 0.75 kg ai metribuzin per hectare or nontreated. Accelerated aging procedure did not reduce either germination or emergence time. No differences were found among treatments in metribuzin damage. No conclusions were drawn from this experiment except that accelerated aging should use preimbibed seeds or be for longer exposure periods to be effective.

2) Effects of Weeds on Soybean Seed Quality

Reports from Brazil and the International Institute of Tropical Agriculture (IITA) have associated poor weed control with production of poor quality soybean seed. We studied the effect of early weed competition and row spacing on development of microorganisms and seed germination in the last grant period.

Previously plots with or without weed communities of johnson grass (*Sorghum halapense*) and morning glory (*Ipomoea tiliacea*) were compared at Lajas and Isabela, respectively. These results showed a marked reduction of seed quality associated with weed presence. In other experiments early season competition reduced yield but did not affect seed quality. Under full season weed competition however decreased both yield and seed quality. This effect was greatest at wide row spacing which permitted increased weed development.

In the current grant period we studied: i) the effect of planting season on seed quality and weed competition; ii) the effect of different weed communities on seed quality during various phenological stages; and iii) the effect of pigweed leachates on soybean growth and development in vitro.

COMPETITION AND SPACING

A weed competition experiment was conducted at Isabela, Puerto Rico during the rainy season (June to October) and during the dry season (October to January) using Williams soybeans planted at 30, 45, and 60 cm row spacings. Subplots were either i) not weeded (full competition); ii) weeded after 5 weeks early competition; iii) weeded after 4 weeks early competition; iv) weeded after 3 weeks early competition or v) weeded after 2 weeks competition. Weed weights, boty dry and fresh, were determined at 2 and 4 weeks after emergence. Fifty seed from each plot was assayed by surface disinfecting them, plating on sterile potato dextrose agar and incubation for 7 days at 25°C. Subplots were replicated three times.

Results from the wet season showed lower germination associated with seeds from the wide row spacing and when weeds were uncontrolled (Table 17). These circumstances also favored increased development of weeds.

Table 17. Mean percent germination of seed sampled from soybean grown in three row spacings and five weed treatments.

Row Spacings (cm)	Weed Control Treatments+ 2	3	4	5	NWR	Mean
30	50.7	51.3	50.0	58.7	30.7	48.3 a*
45	38.0	50.7	43.3	39.3	38.0	41.9 a
60	34.7	36.7	32.7	21.3	18.0	28.7 b
Mean	41.1	46.2	42.0	39.8	28.9	39.6

* Values followed by different letters are significantly different at the 0.05 probability level.

\+ Treatments are designated by number of weeks after emergence and before manual weed removal. NWR indicates no weed removal during season.

Data shows no quality effect associated with early competition. In plots with full-season competition soybean yield was inversely related to competition and positively associated with soybean germination (Table 18).

Table 18. Association of full season competition level in wet season with soybean germination in Williams Soybeans.

Soybean Yield (g) plot	Soybean Germination[w/] (%)
5	0
5	4
20	0
491	12
592	42
882	26
1,022	48
1,055	40
1,243	52

w/ Germination on PDA after surface treatment of seed.

In the wet season seed mycoflora varied according to row distances. Pathogenic fungi associated with low germination (*Fusarium semitectum*, *Colletotrichum dematium* and *Phomopsis* sp.) were more common at wide row spacing, while *Cercospora kikuchii*, which was associated with seed germination (r = 0.88), was found most at the narrow row spacing.

When the same experiment was repeated in the dry season results were distinct. Neither row spacing nor competition level affected germination or infection of seed by microorganisms (Table 19 and 20).

Table 19: Mean percent germination of seed sampled from Williams soybeans grown in the dry season in 3 row spacing and five competition levels.

Row Spacing[w/] (cm)	Weed Treatments[w/]					
	2	3	4	5	NWR	Mean
30	96.0[x/]	93.3	96.0	93.3	96.0	94.9
45	96.7	97.3	98.0	99.3	95.3	97.3
60	90.7	98.0	97.6	94.0	91.3	94.3
Mean	94.5	96.2	97.2	95.5	94.2	95.5

w/ No values differed according F-test.
x/ Based on 100 seed for each of 3 replications.

Table 20: Mean percent *Cercospora kikuchii* from William soybeans grown in 3 row spacings and 5 competition levels during the dry season in 1979-80.

Row Spacing (cm)	Weed Treatment					
	2	3	4	5	NWR	Mean
30	90.7[x/]	91.3	91.3	88.7	85.3	89.5
45	91.3	88.6	94.6	94.6	92.7	92.5
60	89.3	96.0	89.3	88.0	87.3	90.0
Mean	90.4	92.0	91.8	90.4	88.4	90.7

w/ No values differed based on F-test.
x/ Based on PDA germination of 100-seed for each of 3 replications.

Late season but not early season, weed competition interacts with pathogenic microorganisms to increase seed losses during the wet season but not during the dry season.

WEED COMMUNITIES; EFFECT ON SOYBEAN SEED DEVELOPMENT AND QUALITY

Approximately 0.5 hectare was planted to Improved Pelican soybean at Isabela and natural weed populations allowed to develop. Soybeans were planted in late July and harvested in late November. When plants were in late flowering (late September), 3 by 3 meter areas were staked according to dominant weeds present. Dominant weeds were: i) velvet bean (*Mucuna* sp.), morning glory (*Ipomoea tilacea*), jungle rice (*Echinocloa colonum*) crab grass (*Digitaria sanguinalis*), and pigweed (*Amaranthus dubius*). Each community type and weeded controls were replicated three times. At full green bean, yellow bean and at harvest maturities, five plants were harvested from each plot. Seeds were threshed, dried, weighed, rated for damage, and tested on potato dextrose agar for germination and mycoflora.

RESULTS AND DISCUSSION

Yields from plots where weeds were controlled were greater than those found in nonweeded plots. Yield continued to increase from full green bean stage to harvest (Table 21). Velvet bean, morning glory, jungle rice, crab grass, and pigweed caused increasing lower yield. Yield losses ranged from 5 to 85%. Seed damage was associated with those weed communities causing high yield loss. In the weeded control plots seeds had high viability (above 85% germination) in both the full green bean stage and in the yellow bean stages. Viability dropped appreciably at harvest (76% germination). Germination appeared negatively associated with seedborne incidence of fungi.

Compared to weeded plots the velvet bean and morning glory treatments showed a similar change in seed viability with developmental stage; however, decrease in seed germination at harvest was more marked and seedborne incidence of fungi was increased. In communities of jungle rice, crab grass, and pig weed, yield losses exceeded 20%. In these cases, seed quality losses were found in green pod stage. Viability was extremely low especially at harvest. Seedborne incidence of fungi did not account for the total losses in seed viability. For instance, pigweed harvested at full green pod stage had only 50% seedborne fungi and 18% germination. A nonparasitic physiological disturbance of soybeans related to late season weed competition appears extremely important in lowering seed quality.

EFFECT OF PIGWEED LEACHATE ON SOYBEAN DEVELOPMENT

To test for possible allelopathic interaction of pigweed and soybean, Improved Pelican soybeans were grown on soil leachates or leachates of soil planted to pigweed. Pigweed seeds were planted in leonard jars and 3 weeks were allowed for seedling development. Seedlings were then thinned to the three strongest and jar tops were disconnected and the cotton wicks removed. The top half of these jars were then clamped equipment stands and 10 cm pots planted to Improved Pelican soybeans were placed under them. Leonard jar tops with only soil served as controls. Three seed of Improved Pelican were planted in each test pot. Seedlings were thinned to the strongest per pot. Pots were watered indirectly from the leachates of the leonard jars found above. Pots were watered indirectly for 60 days. Each plant constituted an experimental unit and each treatment was replicated 5 times. Plants after two months were analyzed for height, node number, root length, nodulation and dry yield. The experiment

Table 21: Effect of weed and senescene stage on the yield and quality of 'Improved Pelican' soybeans in Isabela, Puerto Rico during the wet season in 1979.

Dominant Associated Weed	Seed Yield (g/5 plants)			Seed Damage (%)			Germ.[x] (%)			Total Seedborne[x] Fungi (%)		
	Green[y]	Yellow[y]	Harvest[y]	Green	Yellow	Harvest	Green	Yellow	Harvest	Green	Yellow	Harvest
None	102.4	115.3	127.6	<2.0	<2.0	2.0	92[z]	88	76	12	26	40
Velvetbean	98.3	108.3	113.3	3.0	2.0	8.0	90	86	62	4	18	56
Morningglory	97.1	96.7	104.5	3.0	5.0	15.0	90	80	36	8	32	68
Jungle rice	64.4	82.6	95.5	10.0	10.0	15.0	76	70	34	26	45	68
Crabgrass	51.8	70.4	68.7	65.0	65.0	65.0	52	18	0	46	45	92
Pigweed	15.7	35.8	49.5	85.0	85.0	85.0	18	8	0	50	81	100

w/ Visual estimate.

x/ Based on germination of surface treated seeds (0.05% NaOCl for 4 minutes) on sterile potato dextrose for 7 days at 25°C.

y/ Green - full green bean stage; yellow - yellow bean stage; and harvest - harvest maturity.

z/ Based on 100-seed per replicate. Three replicates per weed community.

was repeated two times.

RESULTS AND DISCUSSION

Pigweed leachates appeared to reduce plant development (Table 22). Node number height, root length, and dry yield were all less for soybeans under pigweeds than for the control. Pigweed leachates also appeared to lessen nodulation and plants appeared chlortoic in comparison to the control.

Results suggest that alleleopathic substances from pigweeds may be agents reducing the growth and development of soybeans. These substances may also be partly responsible for poor seed development and seed quality of soybeans when growth with pigweeds.

Table 22: The effect of pigweed (*Amaranthus* sp.) leachates on development of 'Improved Pelican' soybeans.

Treatment		Nodes (no.)	Nodules (no.)	Height (cm)	Root Length (cm)	Dry Yield (g)
Pigweed Leachate	$\bar{x}$	6.6	0.2	76.2	53.2	2.85
	s.e.	0.7	0.2	8.0	17.0	0.35
No Leachate	$\bar{x}$	9.4	9.4	128.8	64.4	5.35
	s.e.	0.2	3.7	10.5	18.8	0.85

All means and standard errors of the means based on five plants variety Improved Pelican harvested after two months in the laboratory.

3. Soybean Disease Evaluations

During the grant period evaluations for disease and insect resistance were made for various entries in the INTSOY germplasm testing program. These trials include: ISVEX (International Soybean Variety Evaluation), a test of established varieties worldwide, SPOT (Soybean Preliminary Observation Trial), a test for newly developed materials, SIEVE (Soybean International Experiment Evaluation), a test for developing germplasm in F6 or later, BLT's (Breeding Line Tests), for the advanced breeding lines of the INTSOY project.

For these evaluations, plants were rated twice once at early reproductive stages (R2-R5) and once later near harvest maturity (R6-R8). Percentage of insect defoliation was judged along with prevalence of and severity of common diseases.

RESULTS

Common foliar insects were the following in order of decreasing prevalence: bean leaf beetles (*Ceratoma* sp.), leaf roller (*Heyleptera indica*), velvetbean caterpillar (*Anticarsia* sp.) and leaf weevil (*Diaprepes abbreviatus*). Insect defoliations of 20 to 60% were noted for these even though Diazanon and Sevin were alternated and applied weekly. Although some differences were found

between lines, no lines observed thus far appeared highly resistant. Leaf diseases most prevalent were bacterial pustule (*Xanthomonas phaseoli* var. *sojensis*), which was found most severe in the summer and downy mildew (*Peronospora manshurica*) which appears most heavily under cooler conditions in winter, late fall and early spring. Hardee Late Selection appears immune to both diseases; however, it is susceptible to target spot (*Corynespora cassiicola*). No lines appear with high multiple disease resistance. In cultivated varieties few produce high quality seed under wet season tropical conditions. An apparent exception to this in ACC 2120 (Table 23).

Table 23: Evaluation of ISVEX varieties planted in Isabela, Puerto Rico in July 1979 and harvested in October to November at harvest maturity.

	Germ.	Total Fungi	*Phomopsis* sp.	*Cercospora kikuchii*	Others
ACC 2120	95.5 w/	80.0	14.5	57.0	8.5
Bossier	65.5	94.0	54.5	27.5	12.0
Bragg	74.5	72.0	28.0	39.5	3.5
CH-3	84.5	89.5	36.5	37.5	16.5
Davis	51.5	99.5	59.0	29.5	10.0
Gaysoy	83.5	88.5	24.0	54.5	10.0
Hardee Late Sel.	77.0	67.0	20.5	21.5	25.0
IAC-2	35.0	94.0	15.5	54.0	23.5
Improved Pelican	47.0	91.0	18.0	42.5	31.5
James	77.0	95.0	89.5	12.5	3.0
Orba	57.0	99.0	48.0	49.5	1.5
Ransom	47.0	94.5	78.0	13.0	3.5
Rillito	35.0	100.0	78.0	19.0	2.0
SJ-2	49.0	83.5	38.0	20.5	25.0
Tunia	74.0	85.5	32.5	47.0	6.0
Williams	17.0	100.0	54.0	21.0	25.0

w/ Based on 2-100-seed replicates of each cultivar germinated on cellulose pods at 25°C for 7 days.

DISCUSSION

Disease evaluations of various INTSOY trials shows that there is substantial variation in disease and insect reaction between lines and between seasons. ACC 2120 was the only cultivar which has shown reduced germination losses under field conditions favorable for seedborne fungi. Among ISVEX varieties it was lowest in *Phomopsis* infection (14.5%). Infection of *Phomopsis* and *Fusarium* are closely associated. Seeds of ACC-2120 was heavily infected with *Cercospora kikuchii* the purple stain fungus this shows that resistance to this organism is probably different than that for other seedborne fungi.

4. Effects of Planting Date on Soybean Seed Discolorations in Puerto Rico

The purpose of this study was to examine the influence of planting date and environmental conditions on the development of seed diseases in Puerto Rico. Nine soybean cultivars (Buffalo, Cobb, Davis, Hardee Late Selection, IAC-2, Improved Pelican, Jupiter, Orba and Ransom) were planted at 11 dates (from February 15, 1979 to October 1, 1979). Cultivars were replicated twice in single row plots at each planting date. Plantings were harvested at maturity and numbers of brown stained (anthracnose discolored) and purple stained seed were counted for each of two 100-seed replicates.

RESULTS

Rainfall occurred in two peaks typical of the rainy season in Puerto Rico (Table 25). During the first peak (April through June), anthracnose caused by *Colletotrichum dematium* severely attacked maturing plantings. Heaviest anthracnose was found on the earliest plantings which matured under the heaviest rainfalls. Anthracnose development was not extensive during the August to October rainy period (Table 25).

Purple seed stain varied depending on the cultivar and planting date. The highest overall purple seed stain was found in the cultivar Jupiter (9.8%) and the lowest in cultivars Improved Pelican and Orba (0.8%). Development of purple stain was not associated with precipitation levels but was associated to photoperiod (Table 26).

Mean percentage of purple seed stain for any planting was inversely proportional ($r = 0.86^{**}$) to hours of light on the day of planting. Average purple stain incidence for all cultivars were 11.6, 818, 3.9, and 0.8% for plantings at 11.7, 12.1, 12.5, and 12.9 hours of light, respectively.

DISCUSSION

Anthracnose discoloration of soybean seeds was associated with the first rainy season (April through June) but not the second (August through October) in 1979. The conditions which favor this disease are not purely high humidity and rainfall.

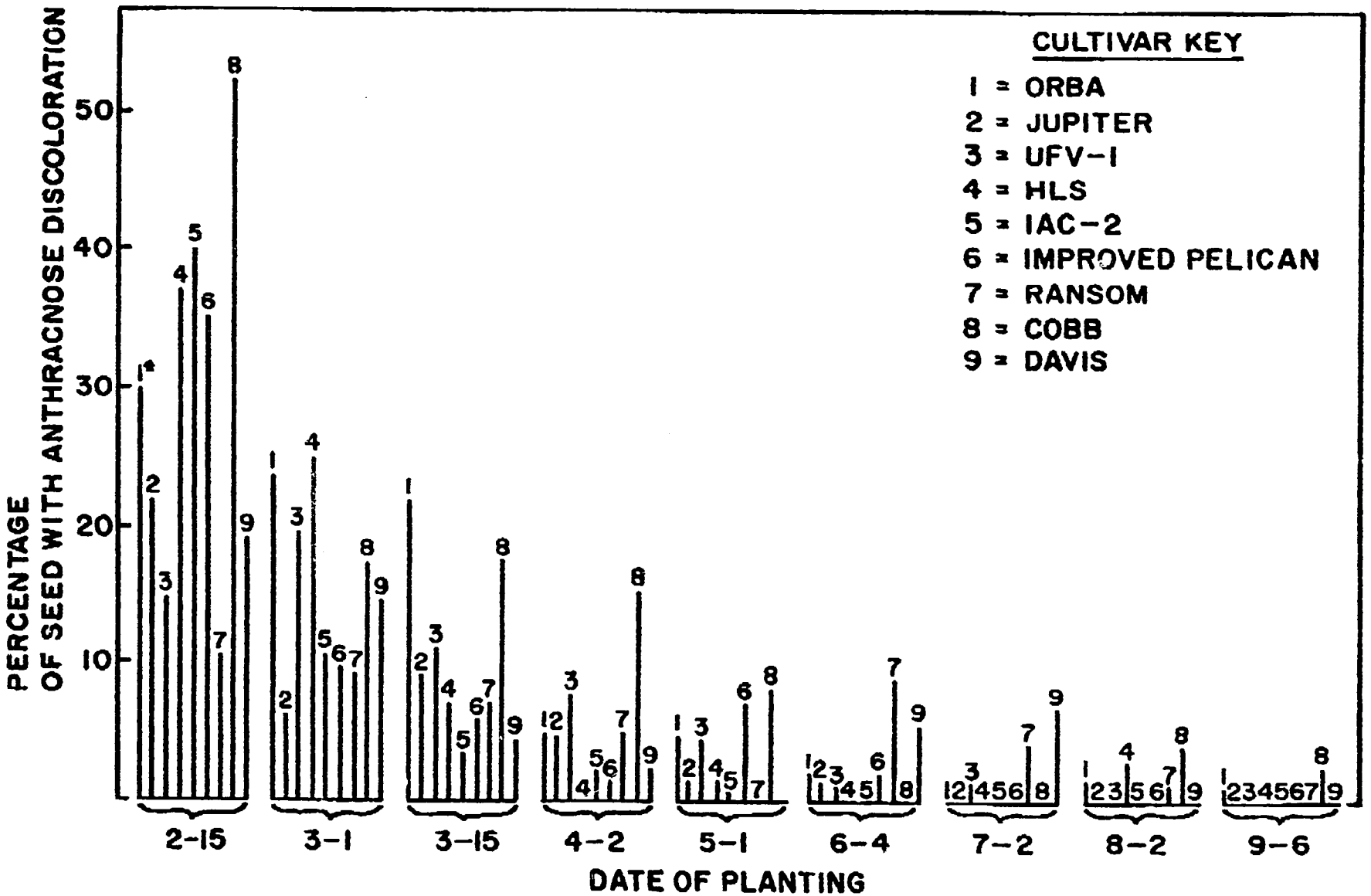
Purple seed development correlated well with day length at planting. Short days (long nights) stimulates early flowering and maturity of soybeans in tropical environments. Varieties Improved Pelican and Orba showed low numbers of purple seed at all dates. Although seeds were not purple, seeds of these

Table 24: Monthly precipitation for the Isabela Substation of the University of Puerto Rico during 1979 and for humid areas of Puerto Rico.

	Isabela (in.)	Puerto Rico[1/] (in.)
January	1.78	4.00
February	1.60	3.80
March	3.60	3.20
April	7.67	5.70
May	10.59	10.20
June	7.70	7.80
July	5.08	7.60
August	3.63	9.30
September	11.16	10.10
October	9.15	9.60
November	8.90	6.70
December	1.58	4.30

1/ Average precipitations for humid areas of Puerto Rico from "Conceptos, Plan y Programa Para Una Agricultura Moderna en Puerto Rico" Vicente Chandler, et. al. Commonwealth Dept. of Agric., 1978.

THE RELATION OF PLANTING DATE TO ANTHRACNOSE SEED DISCOLORATION AT HARVEST IN NINE SOYBEAN CULTIVARS



*EACH MEAN PERCENTAGE IS BASED ON TWO 100-SEED REPLICATIONS

Table 26: The association of planting date with hours of light and purple seed development.

Planting Date	Purple Seed[w/]	Hours of Light at planting
February 15	5.2	11.8
March 1	6.8	12.1
March 15	2.9	12.3
April 2	1.6	12.5
April 17	0.6	12.7
May 1	0.1	13.0
June 4	1.5	13.2
July 2	0.8	12.9
August 2	6.3	12.5
September 6	9.9	12.1
October 6	11.6	11.9

w/ Based on 2 replicates of each of 9 cultivars for each planting.

varieties showed high infection when ISVEX trials were analyzed for seedborne fungi.

5. Viability of Soybean Plant Introductions Selected for Resistance to Seed Microorganisms and Stored for Over Three Years under Ambient Tropical Conditions.

The purpose of this work was to determine the relative viability of some soybean plant introductions which were screened and selected as sources of resistance to seedborne microorganisms. Plant introductions were screened and selected in February 1976 and were found in storage at Mayaguez under ambient conditions November 1979. Seeds from each line (200 each) were germinated for 7 days at 30°C on moist cellulose pads to determine their viability and associated microorganisms.

RESULTS

Aspergillus spp. were the predominant fungi associated with the stored seedlots (Table 27). The extent of *Aspergillus* colonization was associated ($r = 0.98^{**}$) with germination in the seedlots. Smaller seed size of these lines appeared correlated with higher germination and lower *Aspergillus* colonization. Under the same laboratory conditions U.S. cultivars have lost their viability in 6 to 12 months. These seedlots selected for their resistance to seedborne microorganisms were still viable after 3 years storage. Field characteristics of these lines as described by Paschal and Ellis; are included (Table 27). Resistance to seedborne microorganisms was associated with increased storage longevity. The small-seed characteristic may be important to both resistance to seedborne and storage microorganisms. Smaller seed can probably maintain seed humidity more effectively, thus, limiting the development of microorganisms on them either in the field or in storage.

6. Incidence of Seedborne Fusaria in Tropical Soybeans

The objectives of these studies were: 1) to determine the frequency of different *Fusarium* spp. infecting soybean seed in humid Puerto Rico and 2) to determine the relationship of *Fusarium semitectum* to plant and seed symptoms and its effect on seed germination.

During the 1979 rainy season from June to October Davis soybeans were grown at Isabela and Corozal, Puerto Rico. Prior to seed maturity, the fungi on 100-aborted pods from each location were identified. At maturity 24 100-seed lots of each were germinated on cellulose pads and after 7 days at 95% RH and 25°C developing fungi were identified and germination noted. In another experiment Improved Pelican seed from a July planting at Isabela were collected during late pod-fill (R5), at full green pod stage (R6), at pod stage (R7), at harvest maturity and at harvest maturity (R8). Seeds were surface-disinfected with 0.5% NaOCl and plated on potato dextrose agar medium. Internally seedborne *F. semitectum* was determined after 14 days at 25°C. Using Improved Pelican the effect of *F. semitectum* of germination was determined by inoculation green pods with full seed (R6). Pods were surface treated with 0.5% NaOCl for 4 minutes and then inoculated with pure cultures of *F. semitectum*. Inoculum was prepared by scraping mycelium of 10-day-old PDA cultures with 15 ml of added water and grinding with mortar and pestle. Inoculum was applied by

Table 27: The origin, field reactions and storage reactions of soybean plant introductions with resistance to seedborne microorganisms.

Number	Origin	Field Reactions[w/] Percentage Total Seedborne Fungi 0	2	4	Yield (kg/ha)	Maturity (Days)	Lodging	100-Seed weight (g)	Storage[x/] Germ. (%)[y/]	Asp. (%)[z/]
PI 279.088	Tanzania	0	4	11	2597	119	1.7	8.2	49	51
PI 205.912	Thailand	9	9	13	1955	109	2.5	10.6	70	28
PI 341.249	Australia	1	13	20	2741	110	2.0	11.2	76	26
PI 205.907	Thailand	4	7	27	2227	111	1.7	12.1	24	82
PI 239.235	Thailand	2	18	39	2459	119	2.0	11.3	23	77
PI 341.249	Australia	1	13	20	2741	110	2.0	11.2	60	43
PI 219.653	Indonesia	1	14	41	2832	128	3.0	8.2	89	0

w/ Field reactions from Paschal and Ellis Annual Report 1976-1977.

x/ Based on germinations on cellulose pads after 3-years of ambient storage at Mayaguez, Puerto Rico.

y/ GERM. = Germination

z/ ASP. = *Aspergillus* spp.

medicine dropper over wounded or nonwounded pod surfaces. Wounds were produced by a cluster of five 00-gauge insect pins and one drop (0.07 to 0.08) of the fungus was applied on the pod above each developed seed. Four groups of 50 pods per treatment were incubated 5 days. Pods were then immersed in 0.5 NaOCl for 4 minutes and rinsed with sterile water. Seeds were plated on potato dextrose agar.

RESULTS

When aborted pods of soybean cultivar Davi swere assayed at both Corozal and Isabela, a high incidence of *F. semitectum* was found (Table 28). Other fungi which were found at less than 10% incidence were *Colletotrichum dematium*, *Phomopsis* sp., *Botryodiploidia theobromae*, and *Alternaria tenuisima*.

Table 28: Frequency of various fungi on aborted soybean pods cv. Davis

	(%)
Fusarium semitectum	85
Colletotrichum dematium	7
Phomopsis sp.	3
Botryodiploidia theobromae	3
Alternaria tenuissima	2

Based on 200 aborted pods collected in August 1979 from Isabela and Corozal, Puerto Rico.

Fusarium isolates for seed from both Corozal and Isabela showed a high frequency of *F. semitectum* and less than 5% of the isolaes corresponded to four other species. There were *F. oxysporum*, *F. solani*, *F. rigidusculum*, *F. episphaeria* var. *dimerum* (Table 29). The last species constituted less than 1% of the *Fusarium* isolates from seed.

Table 29: Relative frequency of various *Fusarium* species from *Fusarium* infected soybean seed.

Fusarium semitectum	94.0
F. oxysporum	3.0
F. solani	2.0

F. rigidiusculum	0.5
E. episphaeria var. *dimerum*	0.5

Based on 200 *Fusarium* isolates from Corozal or Isabela, Puerto Rico.

Seedlots from Corozal and Isabela that were harvested in October were of low germination and highly infected with a variety of fungi (Table 31). *Phomopsis* sp. was the most frequent fungus over both locations with an incidence of over 30%. *Fusarium semitectum* was second in incidence over all fungi with incidence exceeding 20% at both locations. *Cercospora kikuchii* was at high incidence at Isabela (30.8%) and low incidence at Corozal (0.6%). Incidence of *Colletotrichum dematium*, *Botryodiploidia theobromae*, *Rhizoctonia solani*, and *Corynespora cassicola* did not exceed 10% incidence.

Beyond the incidence of seed fungi their ability to kill seed make them important. The proportion of infected seed which had died was calculated to give an idea of possible pathogenicity. The following formula was used:

$$\text{Lethality} = \frac{\text{Number of fungus infected seed which were dead}}{\text{Total number of seed infected with the fungus}} \times 100$$

Based on fungus lethality and on its incidence, the importance of various seed fungi can be surmised. Based on this method, *F. semitectum* should be considered a highly important fungus slightly less so than *Phomopsis* sp. *Colletotrichum dematium*, *Botryodiploidia theobromae*, *Rhizoctonia solani*, and *Corynespora cassicola* are all highly associated with dead seed but of low incidence. These may be considered of potential importance but of lesser immediate impact on seed quality. *Cercospora kikuchii* which had high incidence and visibility but low association with dead seed should not be considered a problem for commercial seed production.

The frequency of *Fusarium semitectum* increased with seed maturation (Table 32). First infection was found at full green bean stage in Improved Pelican soybean. Greatest increase of seed infection was found after yellow bean stage and in delayed harvest. The rate of *F. semitectum* increase appeared similar to that of total seedborne fungi and inversely related to seed germination.

Table 30: Frequency of *Fusarium semitectum* in soybean seeds cv. Improved Pelican during seed maturation.

	Percentage		
	Fusarium semitectum	Total Fungi	Germination
Pod fill October 30th	0	3	95

	Percentage		
	Fusarium semitectum	Total Fungi	Germination
Full Green Pod November 7th	4	23	90
Full Yellow Pod November 16th	9	37	88
Harvest Maturity November 30th	19	60	45
10 Days after Harvest December 10th	27	100	17

Based on 4 replications 100-seed each.

Pathogenicity tests by inoculation and wounding of pods indicated that inoculation of *F. semitectum* increased pod necrosis and decreased germination compared to the nonwounded and wounded controls (Table 32). Wounding and inoculation completely inhibited germination of seed from pods incubated five days.

Table 31: Effect wounding and inoculation of *Fusarium semitectum* on "Improved Pelican" pod lesions and seed infection.

Treatment	Pod[w/] Lesions	Seed Germination
Nonwounded Noninoculated	5	91
Wounded[y/] Noninoculated	29	80
Nonwounded Inoculated[x/]	75	32
Wounded Inoculated	100	0

[w/] Necrotic areas greater than 4 mm^2 were counted as pod lesion after 5 days at 95 RH and 25°C.

[x/] Based on 4 groups of 50 pods each.

[y/] Wounds by using cluster of 5 insect pins (gauge 00) to

rupture pod surface.

z/ To inoculate *F. semitectum* cultures were scraped with 15 ml water and ground with mortar and pestle. Solution was applied at one drop (0.07 - 0.08 ml.) per inoculation site.

DISCUSSION

Numerous workers have reported *Fusarium* spp. associated with soybean but the species is usually not determined. In Puerto Rico, *F. semitectum* is the predominant *Fusarium* species encountered, followed by *F. oxysporum* and *F. solani*. *F. semitectum* is highly associated with aborted pods which could be an important inoculum source. In previous report it was noted that pod borer damage increased *F. semitectum* incidence in uneaten seed and decreased germination.

F. semitectum was found at high incidence in Davis soybeans at both Corozal and Isabela. Incidence of this fungus was highly associated with dead seed. From lethality and incidence *F. semitectum* is nearly as important as *Phomopsis* sp.

F. semitectum increased in seed beginning in full green bean stage and increasing rapidly after yellow bean stage. This follows a pattern of total seed fungi and is inversely related to germination.

F. semitectum did not need wounds to increase pod necrosis and decrease germination compared to controls which were wounded without inoculation or non-treated. Wounding with inoculation completely inhibited seed germination after 5 days humid incubation.

Previous work by Ellis and coworkers indicated that *F. semitectum* was not pathogenic to healthy dry seed which were inoculated and planted in soil. *F. semitectum* appears very pathogenic to seed in the pod at and after full green bean stage. High percentage of internal infection occurs before maturity and is associated with reduced germination.

Topical application of *F. semitectum* to healthy mature seed does not simulate pod infection and incubation of seed infections in the field. *F. semitectum* appears to reduce soybean germination before the germination process and not during the process as is found in *Phomopsis* sp. infections.

7. Seed Fungi of Winged Bean (*Psophocarpus tetragonolobus*) in Puerto Rico.

Recently winged bean has received considerable attention due to its high content of seed protein and oil which are approximately 38% and 20%, respectively and similar to those of soybean. Unlike soybean winged bean is native to the tropics. Yield of winged beans is superior to that other beans in the tropics except soybean. The foliage, pods, roots, and seeds are all edible. Although winged bean is not a commercialized species, many varieties are used in tropical gardens and sufficient variation exists to develop winged beans of more desirable agronomic characteristics. Although few works have focused on possible production problems, root knot nematodes, anthracnose, and other disease organisms

Table 32: Seed incidence and lethality associated with seedborne *Fusarium semitectum* and other fungi on Davis soybeans produced under humid conditions in Corozal and Isabela, Puerto Rico in October 1979.

Parameters	Percentage Seed			
	Infection		Lethality[x/]	
	Corozal	Isabela	Corozal	Isabela
Germination	35.5 + 2.9[w/]	43.6 + 3.5	64.5	56.4
Fusarium semitectum	23.2 + 2.6	24.7 + 2.5	90.6 + 2.0	68.9 + 4.4
Phomopsis sp.	34.3 + 3.0	33.1 + 3.2	75.2 + 4.3	71.2 + 3.6
Cercospora kikuchii	0.6 + 0.3	30.8 + 3.1	24.0 + 2.7	30.0 + 2.4
Botryodiploidia theobromae	2.8 + 0.8	1.0 + 0.3	97.7 + 2.2	100.0 + 0.0
Colletotrichum dematium	2.8 + 1.0	7.8 + 2.0	90.1 + 9.9	82.8 + 5.9
Rhizoctonia solani	0.3 + 0.2	1.7 + 1.0	100.0 + 0.0	92.5 + 2.7
Corynespora cassicola	7.2 + 1.2	0.2 + 0.1	94.0 + 8.2	100.0 + 0.0

w/ Mean plus or minus standard error of the mean. Means are based on 24-100 seed lots analyzed for germination and seedborne mycoflora on moist cellulose pads at 25°C for 7 days.

x/ Proportion of infected seed which died: Lethality = 100 X $\frac{\text{No. of dead seed infected with a fungus}}{\text{No. of seed living or dead infected by same}}$

may be potentially limiting diseases.

No work has centered on seedborne microorganisms of winged bean or other disease problems in Puerto Rico.

During Jnauary 1980, the Mayaguez Institute of Tropical Agriculture (MITA, USDA, SEA) collection of 20 winged bean accessions was sampled for describing the seed mycoflora of this plant. Four mature pods were selected from each accession, seed were threshed and bulked and 100 seed were germinated on moist cellulose pads at 25°C for 2 weeks. Fungi developing on seeds were identified and germination counts made.

RESULTS

A large number of seeds failed to germinate. These were often covered with brown to bluish masses of *Fusarium* macroconidia, white mycelium, golden brown chlamydospores, and finally orange *Nectria* perithecia. *Fusarium solani* (*Nectria haemattocca*) was identified as the dominant fungus in the seedlot and the only associated with dead seeds. *Phomopsis* sp., the second most common fungus, was only associated with germinating seed. Other fungi were found in less than 5% incidence (Table 33).

Table 33: Germination and incidence of fungi in a winged bean (*Psophocarpus tetragonolobus*) seedlot from 20 winged bean accession grown in Puerto Rico 1979-80.

	Frequency (%)
Germination	74 w/
Fusarium solani	36 y/
Phomopsis sojae	30 z/
Myrothecium spp.	3
Botryodiploidia theobromae	2
Trichocladium sp.	1
Helminthosporium sp.	1
Gliocladium sp.	1
Cladosporum sp.	1
Total Fungi	85

w/ Based on 100-seed from a bulk sample of 20 winged bean accessions.

y/ Seventy six percent of all *Fusarium solani* colonies were on nonviable seeds.

z/ No *P. sojae* colonies were found on nonviable (dead) seeds.

DISCUSSION

Fusarium solani appears seedborne on a wide range of hosts including beans (*Phaseolus* spp.), soybean (*Glycine max*), peanut (*Arachis hypogea*) and many other legumes and nonrelated plants. Winged beans is a newly reported seed host for this fungus. In other legumes especially beans and peas, *F. solani* causes important losses as a root rotting pathogen. *F. solani* appears to contribute to lower winged bean germination. Its potential as a root rot pathogen may be an important hazard to winged bean as cultivation increases.

c. PLANT PATHOLOGY AND WEED SCIENCE
(J. S. Mignucci reporting studies of J. Mendoza)

Soybean anthracnose, caused by *Colletotrichum dematium* appeared in experimental plots at damaging levels in 1979 in Isabela, Puerto Rico. Juan Mendoza, graduate student and research assistant, has followed the development of the disease in subsequent seasons. These experiments are under the direction of Julia Mignucci, pathologist, and Guillermo Riveros, weed scientist.

MATERIALS AND METHODS

The soybean cultivar 'Cobb', highly susceptible to anthracnose, was planted at the Isabela Experimental Substation on March 10, 1980 so that seed development would coincide with the rainy period (May through June). The objectives of the experiment were: i) to determine the effect of different anthracnose levels and weeds on soybean yield and quality; and ii) to study disease dynamics under the same conditions; and finally to iii) to evaluate different number of benomyl sprays for their effect on disease development.

The experiment was arranged in a split plot design, using a six row plot of 23.4 square meters. Subtreatments were as Table 34 and weeded and nonweeded plots were the main plots. Each subtreatment was replicated four times.

Weed Control - Both alachlor (1.5 kg/ha) and metribuzin (0.75 kg/ha) were used to control weeds in weeded plots. Herbicides were applied before emergence and further weed control was done by mechanical hand weedings. Three weedings were given during the experiment's duration.

Weed Assessment - Weed populations were identified in nonweeded plots by species number and fresh and dry weight. Sampling was done by placing a wood frame (0.25 x 0.50 m) three times in each plot.

Inoculation - The four center rows of each designated plot were inoculated with *C. dematium* by spraying plant surfaces with a spore solution of approximately 10^5 spores per millimeter. Conidia were applied by a 4 gallon pack hand sprayer. Inoculum was applied after aerial irrigation of plants and at

Table 34: Description of subtreatments included in weeded and nonweeded plots.

Denomination[1/]	Treatment description for subplots
0/0	Not inoculated and no fungicide spray
0/6	Not inoculated and sprayed[2/] six times
I/0	Inoculated[3/] and no fungicide spray
I/1	Inoculated and sprayed between early and midpod
I/2	Inoculated and sprayed twice at early and at midpod
I/4	Inoculated and sprayed four times at flowering, at early pod, at midpod, and at full pod.

1/ At left of dash (/) the inoculation is specified as I and as 0 for no inoculation. At right of dash, the number of Benomyl sprays is indicated from 0 to 6.

2/ For this treatment, the spray schedule started 2 weeks after emergence and from then on plants were sprayed every two weeks.

3/ Plants were inoculated at the R3 growth stage.

early evening to prevent rapid dessication.

Disease Assessment - Anthracnose lesions and incidence of *Colletotrichum acervuli* were used as criterion to evaluate disease progress in the field. Each of five plants were marked on each of the 4 center rows of each plot. These plants were rated at 27, 34, 48, and 55 days after inoculation. Both stems and pods were rated for area covered with signs or symptoms of anthracnose.

Fifty seeds from each plot were sampled, surface sterilized with 10% clorox, plated on PDA and incubated for 7 days. Both the percent seed with anthracnose and the germination of seed were registered. Another 50 seeds per plot were placed on moist cellulose pads and incubated for 7 days in a germinator at 28°C and 95% RH. Both percentage of seeds germinating and percent seed with acervuli were recorded.

Fungicide Application - The systemic fungicide benomyl was applied at (283 g/ha) using a backpack sprayer as described for inoculum applications. Approximately one liter of fungicide suspension was applied for each plot.

Yield Assessment - The two center rows of each plot were harvested at maturity, and weights were taken and adjusted to 12% humidity based on laboratory measurement of moisture content.

Statistical analysis - All data was analyzed for variance and comparisons between means were made using Duncan's Multiple Range Test.

RESULTS

The most prevalent grasses species, in decreasing order, were *Cenchrus* spp., *Echinocloa colonum*, *Digitaria sanguinalis* and *Eleusine indica*. During the first 60 days of crop development the species of dicotyledonous plants were in order of decreasing prevalence: *Euphorbia heterophylla*, *Oxalis* spp. and *Ipomoea tiliacea* during the last 60 days of soybean development.

Disease incidence on pods of field soybeans that received no fungicide treatment was not different in weeded and nonweeded plots (Table 35). Overall disease incidence increased from the first assessment date to the last, 13.9 to 59.9%, respectively. Seed infection was found higher in nonweeded plots than in weeded counterparts (Table 36). Anthracnose was detected at a higher frequency on moist cellulose pads than on media. In all cases the lowest disease incidence on seeds was found on those from plants sprayed 6 times with fungicide. Detection of differences between treatments seems to be more sensitive when seeds are used compared to visual ratings in the field. Anthracnose inoculation increased seed infection from 3.1% to 36.3% in weeded plots and from 31.3% to 52.5% in nonweeded plots. Fungicide sprays did not significantly control pod or seed infections. Highest seed germination was obtained from seeds from plots which were weeded. Lower germination was found on cellulose pads due to 3 month storage of seed prior to cellulose pad assay. Lower yield were associated with nonweeded plots compared to those which were weeded (Table 36).

Table 35: The progress of anthracnose on pods on field soybeans.

Main Plot[1/]	Sub-plot	Days after inoculation				
		27	34	41	48	55
Weeded	0/0	16.3[3/]	22.5	53.8	48.8	25.5
	I/0	13.8	28.8	61.3	85.0	75.0
	0/6	11.3	21.2	33.8	30.0	27.5
	I/1	10.0	21.2	51.3	66.3	62.5
	I/2	12.5	20.0	65.0	63.8	70.0
	I/4	23.8	27.5	47.5	61.3	78.8
	$\bar{X}$	14.6	23.5	52.1	59.2	56.4
Nonweeded	0/0	12.5	16.3	57.5	52.5	58.8
	I/0	18.8	15.0	61.3	75.0	75.0
	0/6	10.0	12.5	43.8	33.8	42.5
	I/1	13.8	22.5	50.0	70.0	80.0
	I/2	11.3	20.0	36.3	62.5	68.8
	I/4	12.5	16.3	37.5	67.5	55.0
	$\bar{X}$	13.2	17.1	47.7	60.2	63.4

1/ Weeded plots were treated with the preemergence herbicides alachlor and metribuzin and maintained clean by hand weeding.

2/ At left of dash (/) the inoculation is indicated as I and as 0 (zero) for no inoculation. At right of dash the number of fungicide (Benomyl) sprays is indicated from zero to six.

3/ Is the mean of four replicates of 20 plants each.

d. NEMATOLOGY (Nelia Acosta)

1. Symptomatology and Histopathology of *Meloidogyne incognita* on Soybean

A greenhouse experiment was established to verify the resistance and susceptibility of soybean cultivars: Bedford, Bragg, Forrest, Hardee Late Selection, Hutton, and Jupiter to a native population of *Meloidogyne incognita* which was used in the previous year's report. Other objectives of the experiment were i) to describe symptoms associated with root infection, ii) to compare the mode and degree of parasitism between different cultivars, and iii) to determine the effect of the nematode's feeding on the root cells.

MATERIALS, METHODS, AND RESULTS

Forty-eight 12-cm plastic pots were filled with 650 cm^3 of a steam-sterilized sandy soil mixture. A group of eight pots per cultivar were inoculated with 2,100 *M. incognita* eggs per pot and planted with a soybean seedling. All the pots were arranged in a completely-randomized design including eight replicates per treatment and placed on a greenhouse bench for 45 days. Data on root-knot indices nematode numbers were recorded. Segments of primary and lateral roots

Table 36: Soybean yield, seed germination and *C. dematium* infection in weeded and nonweeded main plots and subplots inoculated with *C. dematium* and sprayed with benomyl fungicide.

Treatments		SEED				
		C. dematium (%)		Germination (%)		Yield
Main Plot	Sub-plot	PDA	Cellulose[4/]	PDA	Cellulose	kg/ha
Weeded[1/]	0/0[2/]	2.0[5/]	3.1	38.5[5/]	21.9	2107.9[6/]
	I/0	18.0	36.3	45.0	29.4	1939.3
	0/6	4.0	10.6	36.5	27.5	1669.1
	I/1	16.0	33.1	32.0	19.4	2109.8
	I/2	23.0	41.9	34.5	18.8	1731.7
	I/4	26.0	33.1	26.5	13.8	1912.2
	$\bar{X}$	14.8	26.4	35.5	21.8	1911.7
Nonweeded	0/0	25.5	31.3	26.5	19.4	1450.6
	I/0	33.5	52.5	26.0	23.8	1466.0
	0/6	7.5	6.9	28.5	13.8	1283.1
	I/1	39.0	41.9	27.5	8.8	1315.5
	I/2	26.5	33.8	22.8	21.9	1661.2
	I/4	32.5	37.5	15.5	15.6	2228.8
	$\bar{X}$	27.4	34.0	24.5	17.2	1567.5

1/ Weeded plots were treated with preemergence herbicides and maintained clean by hand weeding.
2/ At left of dash (/) the inoculation is indicated by I and 0 (zero) for no inoculation.
3/ Seeds were surface sterilized and plated on potato dextrose agar (PDA), incubated at 28°C for seven days.
4/ Seeds were placed on wet cellulose pads and incubated at 28°C, 95% RH in a germinator for 7 days.
5/ Mean of four replicates of 50 seeds each.
6/ Mean of four replicates.

were collected from various replicates for histological studies.

Root-knot indices and nematode numbers affirmed the resistant of Hutton compared to the other soybean cultivars tested (Table 37).

Soybean roots for histological examination were stored temporarily in small jars of formalin aceto-alcohol (FAA). Root segments were then cut into 1-cm sections, dehydrated in tertiary butyl alcohol and embedded at 57°C in paraplast. Roots were sectioned longitudinally at a thickness of 1000 mm with a rotary microtome. The section were mounted on glass slides and stained with safranin and fast green for microscopic examination.

Histological examination of root sections did not show differences between cultivars. Longitudinal sections of roots revealed well developed giant cells around the xylem vessels, and females oriented toward them and feeding was apparent in all cultivars. These suggest that differences in susceptibility among cultivars cannot be detected in the early stages of penetration and colonization of the tissue by the nematode larvae. The nature of the resistance in Hutton may be physiological rather than morphological. Further studies should test for other indices of physiological resistance besides reduced population development in the parasitic nematode.

Table 37: Comparison of root-knot indices and total numbers of nematode from six soybean cultivars grown in soil inoculated with 2,100 *Meloidogyne incognita* eggs/plant. (Greenhouse experiment II).

Host	Root-Knot Index (0-5) y/	Nematode Numbers z/ (Root + Soils
Bedford	3.0 A	2,267.0 A
Bragg	2.3 A	2,050.0 A
Forrest	3.0 A	1,483.0 A
H.L.S.	3.3 A	3,150.0 A
Hutton	.8 B	850.0 A
Jupiter	4.0 A	3,567.0 A

z/ Recovered at harvest
y/ Root-knot indix (0-5): 0 = cero, 5 = over 100 galls;
x/ Means (8 replicates per treatment) within each coloumn followed by the same letter do not differ significantly at the 5% level, according to Duncan's New Multiple Range Test.

2. Field Reaction of Soybean Cultivars to Native Nematode Populations

In an attempt to test the susceptibility of 11 soybean cultivars to nematodes in the field, an experiment was established using Bedford, Bossier, Bragg, Cobb, Forrest, Hardee Late Selection, Hutton, Improved Pelican, Jupiter, Santa Maria, and Williams. All cultivars were replicated four times in a partial balanced incomplete block design. Data on nematode population was recorded

e. MICROORGANISMS BORNE IN SOYBEAN SEEDS IN PUERTO RICO (Paul Hepperly)

In 1975 a collection of microorganisms was initiated which were isolated from soybean seed in Puerto Rico. A list of microorganisms identified on soybean seed in Puerto Rico follows (Table 39).

Table 39: Fungi and bacteria identified on soybean seed in Puerto Rico.

Fungi

1. *Acremonium* sp.
2. *Alternaria alternata*
3. *Alternaria tenuissima*
4. *Arthobotrys* sp.
5. *Arthrinium* sp.
6. *Ascotricha* sp.
7. *Aspergillus chevaliere*
8. *A. flavus*
9. *A. niger*
10. *A. oryzae*
11. *A. sidowii*
12. *Botryodiploidia theobromae*
13. *Cercospora kikuchii*
14. *Chaetomium cuprinum*
15. *Chaetomium globosum*
16. *Chaetophoma* sp.
17. *Choanphora* sp.
18. *Cladosporium cladosporioides*
19. *Colletotrichum dematium*
20. *Colletotrichum gloeosporioides*
21. *Colletotrichum acutatum*
22. *Corynespora cassiicola*
23. *Curvularia lunata*
24. *Dendryphiopsis* sp.
25. *Drechslera* sp.
26. *Epicoccum* sp.
27. *Eremascus* sp.
28. *Fusarium episphaeria*
29. *Fusarium oxysporum*
30. *Fusarium rigidiusculum*
31. *Gliocladium roseum*
32. *Harpographium* sp.
33. *Helminthosporium* sp.
34. *Leptosphaerulina* sp.
35. *Macrophoma* sp.
36. *Macrophomina phaseolina*
37. *Melanospora* sp.
38. *Monilia* sp.
39. *Mucor* sp.
40. *Myrothecium roridum*
41. *Nematospora coryli*
42. *Nigrospora oryzae*
43. *Nodulosporium* sp.
44. *Papularia* sp.
45. *Penicillium notatum*
46. *Penicillium* sp.
47. *Periconia minutissima*
48. *Pestalotia* sp.
49. *Phialospora gregata*
50. *Phoma herbarium*
51. *Phomopsis* sp.
52. *Pyrenochaeta* sp.
53. *Rhizoctonia solani*
54. *Rhizopus nigricans*
55. *Rhodotorula* sp.
56. *Rosellina* sp.
57. *Sclerotium rolfsii*
58. *Syncephalastrum* sp.
59. *Trichocladium* sp.
60. *Trichoderma* sp.
61. *Trichothecium roseum*
62. *Tubercularia* sp.
63. *Vermicularia* sp.
64. *Xylaria* sp.

Bacteria

1. *Bacillus subtilus*
2. *Pseudomonas glycinea*
3. *Pseudomonas tabaci*
4. *Xanthomonas phaseoli* var. *sojensis*

from the soil and roots after five months. Data on yield was collected and analyzed.

There was no significant difference among the cultivars for any of the parameters. Bedford had the highest yields (175 kg/plot) and Hutton the lowest (175 g/plot) (Table 38). The low yield of Hutton was associated with low germination and field emergence.

Although soybeans have been continually cropped for over 7 years at Isabela, a serious natural infestation has yet to be identified. Although soybean plants are quite susceptible to *Meloidogyne incognita* in the greenhouse field populations are mainly *Rotylenchulus reniformis* which has not been associated with reduced soybean growth here.

Table 38: Means of numbers of nematodes and yield per plot in a field experiment on the susceptibility of 11 soybean cultivars to nematodes, mainly *Rotylenchulus reniformis*.

Soybean Cultivars	Yield[z/] (kg)	Number of nematodes (250 cm^3 soil)
Bedford	174.89	2320
Bossier	124.66	3340
Bragg	75.45	1213
Cobb	69.43	460
Forrest	149.77	380
Hardee Late Selection	85.68	2453
Hutton	40.91	300
Improved Pelican	113.18	480
Jupiter	113.64	3480
Santa Maria	127.61	1360
Williams	104.09	2427

z/ There was no positive correlation between nematode population and yields.

II. EDUCATION AND TRAINING

The use of grant researchers in teaching training was a major objective of this grant. Grant researchers and financial resources helped establish a new Department of Crop Protection beginning in 1976. The Department of Crop Protection at the University of Puerto Rico Mayaguez Campus employs 56 scientists (26 Ph.D's and 30 at the M.S. level). The new department seeks to intergrate activities of plant pathology, nematology, entomology, weed science and pesticide usage and toxicology in one program. There are over 30 graduate students pursuing Master's degrees in this field.

The Department of Crop Protection teaches over 20 courses. The grant staff has

taught the following: 1) Introduction to Plant Pathology, 2) Methods in Plant Pathology, 3) Current Theories in Plant Pathology, 4) Phytopathogenic Fungi, 5) Weed Science, 6) Physiology of Herbicide Action, 7) Tropical Agronematology and 8) Control of Phytopathogenic Nematodes.

Through the grant, graduate research of Latin American students has been supported. Many of these students return to work in national projects on grain legume development. These students and their topics of research are listed (Table 40).

Table 40: Graduate students who received aid through AID/CM/TA-G-73-50 1974-1980.

Name	Country	Research Topic
Ivonne Shattuck	Puerto Rico	Histopathology of Purple Seed Stain in Soybean
Fredico Cuebas	Dominican Republic	Mutagenicity of 5-bromdeoxyuridine to Soybean
Ernest Leypon	Nicaragua	Etiology and Control of Soybean Bacterial Spots
José Arrieta	Colombia	Survey of Phytoparasitic Nematodes in Soybean
José Gonzalez	Nicaragua	Epidemiology and Control of Purple Seed Stain
Ricardo Leon	Guatemala	Planting Date and Location on Soybean Yield
Cesar Hanania	El Salvador	Root Knot Nematode Control on Soybeans
Miguel López	Nicaragua	Races of Field Bean Rust in Puerto Rico
Osvaldo Zambrano	Ecuador	Effect of Seedborne Fungi on Soybean Quality
Emilio Salaues	Bolivia	Photoperiodicity of Soybeans in Puerto Rico
Juan Mendoza	Honduras	Anthracnose Disease Development in Soybeans

One of INTSOY's programs has been aimed at increasing the national production

of soybean in Perú. Four Peruvians have received advanced training at the University of Puerto Rico in Mayaguez under the guidance of grant staff. The grant has provided the bulk of materials, laboratory and field space for the realization of graduate research for these students. All have now returned to the national program in Perú. They were:

a. Otoniel Mendoza, who worked on herbicidal control of weeds in soybean and methods of increasing the selectivity of metribuzin.

b. Americo Celada, who worked on effects of spacing and density on soybean-weed competition and light interception.

c. Gonzalo del Rio, who worked on effects of seedbed environment and inoculum type on soybean nodulation by *Rhizobium japonicum*.

d. Homer Tuesta, who conducted research on soybean-corn intercropping.

An excellent student exchange developed between the University of Illinois and the University of Puerto Rico. This was largely due to the grant and the resultant soybean program. Puerto Ricans who studied at the University of Illinois and returned to strengthen the University of Puerto Rico are:

a. Jaime Jordan, who completed a doctorate working in weed science. He returned first as head of the Isabela substation and later as Chancellor of the Utuado campus of the University of Puerto Rico.

b. Nelia Acosta, who completed her doctorate in nematology and returned as an investigator and later as Head of the Department of Crop Protection.

c. Julia Mignucci, who completed a doctorate in plant pathology, and is now coordinating research and teaching.

d. Arcangel Rodríguez, who completed his Master's degree in plant pathology and now is working on rice, avocado, and root crop diseases and their control.

A number of Illinois students did a major portion of their thesis research at the University of Puerto Rico Mayaguez. These included:

a. Frank Tenne, who worked on foliar fungicides as controls for tropical diseases of soybean.

b. Steve Foor, who worked on seed viability and storage under tropical conditions.

c. Pornpod Thongmeearkom, who worked on effects of cowpea mosaic virus on soybean yield.

d. Glenn Bowers, who worked on resistance of soybeans to soybean mosaic virus.

e. Peerasok Srinives, who worked on inheritance of hard-seededness in soybeans.

f. Roger Elmore, who worked on soybean-sorghum inter-cropping.

g. Gary Brinkman, who worked on aluminum toxity in soybeans.

h. Novianti Wiradaryn, who worked on soybean response to nitrogen and inoculation with *Rhizobium japonicum*.

Unlike work done at many other Land Grant Universities, research at the University of Puerto Rico is directly applicable to tropical problems.

III. ADVISORY CAPACITY

Increased advisory capacity resulting from grant investments have been shown in a number of ways. Grant staff has participated in short courses on soybean production and protection in and for lesser developed countries. During the last grant period grant staff were active teachers in the short course for Soybean Production in Latin America held in Palmira, Colombia by ICA-INTSOY-AID. Guillermo Riveros has worked on weed control as a consultant for the National Program in Perú to increasing soybean production there. The project has responded to several inquiries on methods of resolving specific pest problems on soybean mainly from peace crop workers, CARE workers and FAO workers most of these have come from Latin America.

IV. INFORMATIONAL CAPACITY

Linkages were made with various institutions on the international, national and state levels during the grant period. These linkages have been described in previous grant reports.

Research results have been extended by formal presentation at technical meetings and workshops, by formal publication, and by INTSOY publications. INTSOY Newsletter 23 and 24 covered work in the areas of pathology and weed science carried on at Puerto Rico during the grant period.

V. GRANT IMPACT AND RESOURCES

Grant funding has had a positive effect in the development of the capacity of UPR/MC in dealing with crop protection of grain legumes.

Teaching and research facilities were developed under the grant which nurtured the development of the Department of Crop Protection.

Investment with federal funds was matched by commits of state funds in the project area.

In direct support of the grant UPR/MC provided:

1. Administrativecosts including salaries and utilities in administrative offices.

2. Class rooms, library, field space and facilities, office space, and laboratory space and utilities have been provided by UPR/MC. All facilities of the Agricultural Experiment Station have been made available to grant personnel and for grant related activities. The services of Central Analytical Laboratory and the Nuclear Center were also available.

These contributions have shown the strong commitment of the University of this program.

VI. INVOLVEMENT OF MINORITY PERSONNEL AND WOMEN

The University of Puerto Rico has been an affirmative action and equal opportunity employer. Qualified women have been found at all personnel levels in the program. Grant staff is equally divided in men and women.