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ANNUAL REPORT

ON

DEVELOPMENT OF IMPROVED HIGH-YIELDING SORGHUM CULTIVARS

CONTRACT NO. AID/ta-C-1027

June 1, 1975 - May 31, 1976

Prepared by:

Puerto Rico Agricultural Experiment Station
College of Agricultural Sciences
University of Puerto Rico
Mayaguez Campus
Mayaguez, Puerto Rico

Cooperators:

Mayaguez Institute of Tropical Agriculture

and

Texas Agricultural Experiment Station

Submitted to:

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A - SUMMARY

1. Project Title and Contract Number:

   Development of Improved High-Yielding Sorghum Cultivars

   Contract No. AID/ta-C-1087

2. Principal Investigators:

   Abad Morales
   Carlos Cruz
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3. Contractor's Address

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4. Contract Period: June 1, 1974 to May 31, 1977

5. Reporting Period: June 1, 1975 to May 31, 1976

6. Total Expenditures and Obligations Through Previous Contract Years:

   $46,668.74

7. Total Expenditures and Obligations for Current Contract Year:

   $68,031.26

8. Narrative Summary of Accomplishments and Utilization:

Grain sorghum for human consumption offers a vast potential throughout the tropics and sub-tropics. Excellent grain yields may be obtained by using high yielding cultivars highly resistant to insects and diseases under adequate management practices.

Sources of resistance to most of the sorghum pests have already been identified.

Grain and forage sorghum cultivars are being evaluated for yield, resistance to diseases, insects and nematodes and agronomic performance.

It has been found that the most important diseases attacking sorghum in Puerto Rico are Helminthosporium blight, anthracnose, rust, stalk rot and the zonate leaf spot. Smut infections have been sporadic and mostly observed in the Mayaguez area.

An unreported leafspot disease of sorghum was first observed at the Lajas Experiment Substation. Pycnidia of the fungus Coniothyrium zeae stout are consistently associated with these spots. In Mayaguez, pseudothecia of Paraphaeosphaeria O. Ericks were found in the spots along with the pycnidia. This genus includes the sexual stages of Coniothyrium species.

Rust, as mentioned above, is one of the most serious diseases of sorghum, expecially on some cultivars. Lines previously reported as being highly resistant to rust were evaluated. Of these, some were observed to have a high degree of susceptibility.

Grain quality is extremely important. Apparently this character is affected to some extent by seed borne pathogens. A detailed analysis of the fungi borne in the seed of five sorghum lines is about to be completed. Tests for pathogenicity of the main fungus species are underway. A study of the possible correlations between the fungi found in seeds and foliar disease incidence, seed color, seed germination, seedling diseases, time of harvest, growth environment, seed treatment and the effect of bagging of the inflorescence on seed quality for 20 sorghum lines is also underway. Screening methods for stalkrot resistance are under study.

The following insect pests have been found attacking the sorghum plantings in Puerto Rico: fall armyworm, corn ear worm, sorghum webworm, and sugarcane moth borer. Some other insects, such as aphids, plant bugs, chinch bugs, scale insects, and sorghum midge, are commonly found. Preliminary observations have shown some evidence of plant resistance to some of these insects.

Nematodes also take a toll from sorghum growers. Various nematode species were found in a field study at four locations. Pratylenchus zeae was considered the most important parasite of sorghum under local conditions as based on its virulence, its populations and distribution. When total mixed populations were considered, soil pH did not seem to have any effect, but populations of P. zeae were much higher in neutral soils than in acid soils. Populations were higher at locations of low temperatures and light soils than in those when high temperature and heavy soils prevail. In a greenhouse experiment, an inoculum of 1500 P. zeae was pathogenic on sorghum, producing pronounced necrosis of the roots, thus reducing significantly top and root fresh and dry weights.

Forage sorghum hybrids were grown at two locations. Hybrids SX-16, SX-17, Grazer A, Pioneer 988 and Pioneer 979 did well at both locations. However, their performance was better in an Oxisol than in an Ultisol.

B - PROJECT OBJECTIVES

The main objective of this project is to develop and make available to LDC's high yielding cultivars of sorghum with improved nutritional value and multiple resistance to prevalent diseases and insects. An auxiliary objective is to develop improved cultural practices for sorghum in the tropics and sub-tropics.

C - ACCOMPLISHMENTS TO DATE

Findings

1- Phytopathology

Sorghum converted lines and plants from the "All Disease Nursery" were evaluated for resistance to the most important diseases at two locations.

a) Sorghum converted lines:

IS 3477; 3574, 6845, 7518, 7542, 6512, 7776, 12573 and 12588 appeared to be resistant to Helminthosporium blight at the Lajas Agricultural Experiment Substation. Lines IS 530, 1134, 1159, 3574, 3625, 7541, 7612, 7809, 12573, 12602, 12638 and 12756 showed the best overall resistance to Helminthosporium blight, anthracnose and rust (Appendix 1). These same lines were evaluated at the Isabela farm of the Mayaguez Institute of Tropical Agriculture. A higher number of lines showed resistance to Helminthosporium blight, anthracnose and rust at Isabela (Appendix 2). The evaluations at both locations were made under natural infestation and apparently this was lighter at Isabela. In addition to the three above mentioned diseases, these lines were also evaluated for Gloeocercospora at Isabela.

b) The "All Disease Nursery":

Preliminary evaluations under natural infestation were also made on the "All Disease Nursery" at two locations. These evaluations confirmed that the most important foliar diseases attacking sorghum in Puerto Rico are Helminthosporium blight, anthracnose, rust and the zonate leaf spot (Appendixes 3 & 4). Lines showing good resistance to the first three diseases at Lajas were SC 110-14, 334-9-p1, 239-14, 120-14-1, 935-6, 11-9, 170-6-8-3, Tam 2567, 817-3, IS 2930 x IS 3922

In general, plants at Isabela showed a higher degree of resistance (Appendix 4).

Lines with good overall resistance and lines resistant to a particular disease have been selected for further evaluation. The most resistant lines, together with those showing other good agronomic characters, will be used in developing a population.

c) Disease ratings of sorghum lines from population PR-2:

This population is being developed by the Mayaguez Institute of Tropical Agriculture. Ratings of all the components are presented in Appendix 5. The following lines showed good resistance to three different diseases:

Helminthosporium	Anthracnose	Rust
SC 0599-6-3	ADN 143	SC 0326-6
Tam 2566	IS 10542	IS 12539c
ADN 288	ADN 101	IS 6882c
	ADN 121	
	IS 12539c	
	IS 6882c	

Lines showing good balanced resistance to all three diseases were: IS 6882c, ADN 288, IS 12556c, IS 6906c and TAM 2566.

d) Foliar disease ratings of some sorghum lines (some selected by Dr. F. Miller plus other three entries):

Ten lines selected by Dr. Fred Miller, a commercial cultivar from El Salvador and two other hybrids were planted in field plots following a randomized block design and evaluated for Helminthosporium blight, anthracnose, rust and bacterial stripe. Ratings on these plants are presented in Appendix 6. Lines ADN 155 and 156 showed the highest degree of resistance to all four diseases. Cultivar Centa S-1 showed good resistanc to anthracnose and bacterial stripe, but was susceptible to rust and Helminthosporium blight.

e) Rust infection at Isabela:

Several lines previously reported as resistant to rust (Appendix 7) were evaluated and some of them showed a high degree of susceptibility to the disease. Lines IS 6919, 3758, 2549 and 3579 were highly resistant; and lines IS 2651, 3515, 6992, 2990, 2991, and 910 were intermediate. Apparently, a change in the race complex of this organism has occurred; or differences in environment at the time of reading were responsible for the changes in reaction.

f) Seed-borne diseases.

Seed quality is probably affected by environmental factors as well as by seed borne diseases. A detailed analysis of the fungi borne in the seed of five sorghum lines has been made. Tests for pathogenicity of the main fungus species are underway. Also, correlations between the fungi in seed and foliar disease incidence, seed color, seed germination, seedling diseases, time of harvest, environmental factors, seed treatment, and the effect of bagging the inflorescence on seed quality for 20 sorghum lines are underway. Sufficient data have been gathered on seed-borne fungal pathogens in sorghum and a manuscript is being prepared for publication. The most important findings thus far are that Fusarium moniliforme is by far the most frequently isolated species and that it is also the most virulent among the species tested. Based on these findings some experiments have been designed to study the relationship between F. moniliforme and the sorghum plant. The first experiment involves peduncle inoculation, at half bloom, of male parents and F_1 plants in a diallel cross. The objectives are: 1) to estimate heritability and inheritance patherns of F. moniliforme

stalk rot resistance; 2) to determine potential yield losses due to peduncle infections occurring at half bloom; 3) to determine the effect of peduncle infections on grain characteristics, and 4) to study the possibility of grain infection via de vascular tissue.

Inoculations have been made and data on the following will soon be taken: 1) yield, 2) 100-seed weight, 3) test weight, 4) seed density (alcohol displacement method), 5) seed weathering rate, 6) % germination in sand beds, 7) % seedling blight, 8) shoot length, 9) root length, 10) % pre-emergence damping off, 11) % root rot, 12) % germination in PDA plates, 13) % seeds with fungi, 14) % seeds with F. moniliforme, 15) peduncle density, 16) peduncle stress tolerance. In all cases, comparisons will be made between inoculated peduncles and non-inoculated controls.

The second experiment is designed to evaluate a simple method for screening breeding lines for F. moniliforme resistance, and the effect of various inocula concentrations applied to seed on seed germination and seedling development. A single cultivar (TAM 428) was inoculated with spore suspensions in water at five different concentrations and the corresponding killed-spore controls. Individual seeds are being grown in moist sterile sand in vials. The following data are being taken: 1) % germination, 2) % damping off, 3) % root rot, 4) root length, 5) shoot length, 6) % seedlings with isolate F. moniliforme.

g) New disease:

An unreported leafspot disease of sorghum was first observed in May at the Lajas Experiment Substation. The typical symptom is an oval to oblong light-brown necrotic spot approximately 2 x 1 cm with a rust pustule at its center. The color of the sharply, defined spot margin varies with plant color. An indistinct yellow halo is frequently observed up to 0.5 cm beyond the margin of the spot.

Pycnidia of the fungus Coniothyrium zeae stout are consistently associated with these spots. In Mayaguez, pseudothecia of Paraphaeosphaeria O. Eriks were found in the spots along the pycnidia. This genus includes the sexual stages of Coniothyrium species. The species identification was tentatively confirmed by microscopic comparison with the type specimen received from the Illinois Natural History Survey. A detailed comparison, using scanning electron microscopy of spore ornamentation, will be made.

Gray sterile colonies have been isolated frequently from germinating pycnidiospores and lesion margins, but pathogenicity tests have not yet been attempted.

This, as with many other Coniothyrium species, appears to be an aggressive secondary invader which can worsen the damage caused by rust and possibly other diseases. Though the disease appears to be of little economic importance it can be a problem for plant pathologists and plant breeders conducting disease evaluations because its symptoms sometimes mimic those of

other diseases. For example, when the fungus enters the plant through a rust pustule located on the underside of the midrib it produces, on the upperside, a lesion similar to anthracnose.

Pathogenicity test will be carried out to determine if the organism in question is C. zeae.

h) Sorghum seed storage:

Planning and design of an experiment to evaluate simple methods for producing and storing high quality sorghum seed in the hot humid tropics have been completed. The variables include: a) harvest at physiological maturity and at three weeks after physiological maturity; b) treatment with and without charcoal; c) sun drying and air drying, d) storage in sealed plastic bags and in cloth bags, and 3) storage for 0, 3, 6, and 9 months. There will be three replicates of each of the 64 treatments. The following data will be obtained: 1) % moisture; 2) 1000-seed weight, 3) seed density, 5) % emergence in sand bed, 6) % root rot, 7) % seedling blight, 8) root length, 9) shoot length, 10) germination in PDA plates, and 11) % of seed infested by a particular fungus species.

2- Entomology

Preliminary studies of the insect pests attacking sorghum in Puerto Rico have demonstrated that most of these insects are already known in other countries. However, the relative importance of these insect pests seem to be different from that in the United States and other countries. In Puerto Rico, the fall armyworm, Spodoptera frugiperda (J.E. Smith); the corn ear worm, Heliothis zea (Fabricius); and the sorghum webworm, (Unidentified species) apparently are the most important insects attacking sorghum. The sorghum midge has been observed sporadically. The sugarcane borer Diatraea saccharalis and the lesser cornstalk borer, Elasmopalpus lisnosellus (Zeller) should be studied to determine the magnitude of their damage. Other insects commonly found are the corn aphid, Rhopalosiphum maidis (Fitch) chinch bugs, and scale insects.

Most of the insects are present the year around. Plant bugs have been found in all plantings, particularly in plants with compact and solid heads. Even with high populations of these insects, damage seems to be negligible. The sorghum webworm appears when the sorghum grains are dry. This insect destroys a high percentage of the dry seeds and control studies should be conducted.

A series of lines selected by Dr. F. Miller and three additional entries were evaluated for webworm and fall armyworm damage (Appendix 8). It was found that lines ADN 155, ADN 250, ADN 156 and hybrid NK 233 were the less affected. Among the most affected were SC 175-679-2, Centa S-1, SC 175-14E and ADN 232.

Evaluations were also made of the reaction of several sorghum lines to the fall armyworm, the sugarcane borer (Appendix 9) and the corn earworm.

The fall armyworm attacks mainly young plants and susceptible ones should be protected to avoid heavy damage. Preliminary observations reveal that resistance may be present in some of the lines studied.

The sugarcane borer attacks mostly mature plants and apparently has little effect on grain yield. Sampling of 5 stems per line showed that there are differences between lines. Through careful selection cultivars with a high degree of resistance may be obtained.

In small experimental plots, damage caused by birds is considerable. In order to save seed from desirable lines and get self-fertile seeds plants must be bagged. Apparently, bagging affects the insect population in sorghum heads. Three experimental plantings were sampled and the effect of bagging studied. The study showed that 72 to 100% of bagged heads were infested with different insect species, while only 30 to 50% of unbagged heads were infested. The infestations with the corn earworm ranged from 48 to 96% in bagged heads. Only 0-15% of unbagged heads were infested.

Infestation with the sorghum webworm was 10-36% in bagged and 0-12% in unbagg d heads.

Aphids infestation ranged from 44 to 72% in bagged heads while in unbagged heads was 0 to 5%.

Plant bugs were about the same in both bagged and unbagged heads.

These data were gathered in unsprayed plantings, thus, demostrating the importance of natural enemies in controlling sorghum insects. It is evident that bagging protects insect pests.

3- Nematology

a) Nematodes associated with sorghum:

In a field study at the Fortuna and Lajas Agricultural Experiment Substations and at the experimental farms of the Mayaguez Institute of Tropical Agriculture at Mayaguez and Isabela, the phytoparasitic nematodes most commonly isolated from the rhizosphere of sorghum were: *Pratylenchus zeae*, *Helicotylenchus* sp., *Tylenchorhynchus crassycaudatus*, *Aphelenchus* sp., *Aphelenchoides* sp., and *Tylenchus* sp. All but *T. crassycaudatus* were present at the four locations. The lesion nematodes, *P. zeae* was considered the most important species associated with sorghum in the areas under study because its populations were usually high and were present in most samples. However, a complete picture could not be obtained because root samples were not processed due to difficulties encountered.

Tylenchorhynchus could be an important parasite of sorghum as it has been reported in related crops such as corn and sudan grass.

Some of the nematode genera isolated are merely suspected parasites and their importance as plant pathogens have not been established as yet. Such genera as Aphelenchus and Tylenchus were frequently isolated from soil samples at most of the locations studied.

Although in general, soil pH did not seem to influence mixed populations of phytoparasitic genera, P. zeae was more numerous (792/250 cc of soil) in the neutral soils (pH 7.26) of Fortuna than in the acid soils (pH 4.41) of Isabela (447/250 cc). This tends to indicate that the nematode reproduces and survives better in soils with a pH close to neutral than in acid soils.

Temperature exerts great influence over nematode survival and reproduction. Although in these studies this seemed to be the case the methods employed can not support a final conclusion because soil temperature was not recorded for a reasonable length of time. However, average air temperature in the south coast (Fortuna and Lajas) is a few degrees higher than in the Northwestern coast (Isabela).

Soil type has a direct effect over nematode survival, activity and motility; different nematode species appear to differ in their preference for lighter or heavier soils. The influence of soil type on plant parasitic nematodes is a highly complex problem because physical and chemical factors vary so greatly between different locations. Data on these studies are presented in Appendixes 10, 11, 12 and 13.

In a greenhouse experiment designed to study the effect of P. zeae separately and in combination with four soil fungi on sorghum, an inoculum of 1500 P. zeae was pathogenic on sorghum, producing pronounced necrosis of the roots (Appendix 14) and reducing significantly top and root fresh and dry weights. The top dry weight was reduced significantly also by the combinations P. zeae-Curvularia spp. P. zeae-F. moniliforme, P. zeae-Rhizoctonia solani, and P. zeae-Macrophormina sp., by F. moliniforme and by R. solani, alone. These results suggest that the lesion nematode and the four fungi under study are pathogenic on sorghum. However, the symptoms observed under field conditions were not reproduced in the greenhouse.

As expected, the population levels of P. zeae were much higher in the roots than in the soil. There was no apparent effect of competition from the different fungi on the reproduction of the lesion nematode as demonstrated by final populations.

Data from a second experiment to evaluate the effect of P. zeae alone and in combination with Curvularia spp. and F. monififorme are given in Appendix 15. A concentration of 750 P. zeae was used. Plant growth was not

affected by nematodes or fungi alone or by combinations of them. Fusarium moniliforme alone or in combination with P. zeae reduced the root dry weights by 63 and 64%, respectively. Under the conditions prevailing, only F. moniliforme was pathogenic to sorghum roots. Reduction of root development by P. zeae was not significant suggesting that the inoculum used (750 specimens/plant) was below the critical level.

4- Cultural practices

Evaluation of Preemergent Herbicides in Sorghum at Lajas

Grain sorghum SC 175-14 E was drill-seeded on January 28, 1976 at the Lajas Agricultural Experiment Substation following a randomized complete block design with four replications. The experiment was established in a Vertisol (San Anton silty clay). Plot size was 1.52 m (2 rows, 2.5 ft. apart) x 6.10 m (20 ft) long. A 15-5-10 N P K fertilizer was banded at the rate of 2 metric tons per hectare.

Preemergent herbicides were broadcast-sprayed on January 29 with an air pressurized field plot sprayer, set at 2 kg/sq. cm, equipped with 8005E Teejet tips delivering one liter of herbicide preparation per plot.

Treatments were as follows: 1) Metribuzin, 4- amino-6-tert-butyl-3-(methylthio)-as-triazine -5 (4 H) one at 1.12 kg a.i./ha; (2) Bifenox, methyl 5- (2,4-dichlorophenoxy) -2- nitrobenzoate at 2.24 kg; 3) DPX 3674 (Velpar TM) 3-Cyclohexenyl -6-dimethylamino -1-methyl -s- triazine -2,4 (1 H, 3H) -dione at 2.24 kg; 4) Linuron, 3- (3,4-dichlorophenyl) -1-methoxy -1-methylurea at 3.36 kg; 5) Atrazine, 2-chloro -4- (ethylamino)-6- insopropylamino -s- triazine at 3.36 kg; 6) Propazine, 2 -chloro -4,6- bis (isopropylamino) -s- triazine at 3.36 kg; 7) Linuron (1.12) plus Propazine (2.24 kg); 8) Atrazine (1.68) plus Terbutryn, 2- (tert-butylamino)-4-(ethylamino)-6- (methylthio) -s- triazine (1.68 kg); 9) hand-weeded check; and 10) non-weeded check. Atrazine, Propazine, and Atrazine plus Terbutryn were the most effective herbicide treatments for sorghum at the Lajas Substation farm during the 1975 trials and therefore were retained for further evaluation along with other chemicals. Since good weed control was attained with the different weed killers, except for nut grass (Cyperus rotundus L.), an application of 2,4-D (dichlorophenoxy) acetic acid at 0.5 kg/ha on February 12 was needed.

Due to severe bird damage to sorghum panicles in all plots, no grain yields could be recorded. Table 16 presents data on weed control, average number of panicles per plot, and green weight of plants (stalks, leaves and panicles). In sample determinations, panicles averaged 25 gm of grain for "acceptable size" and 6 gm grain for "inferior size". Symptoms of herbicide toxicity to plants were observed for Velpar and Linuron treatments. These were more severe for Velpar, reducing plant population about 50 percent. Data on green weight and total panicles for Velpar treatment further confirm this observation.

5- Forage sorghum evaluations

A - Agronomic evaluations of eight sorghum x sudan grass hybrids and "Millo Blanco" in two locations.

A field experiment to evaluate the yield potential of eight sorghum x sudan grass hybrids obtained from various commercial enterprises and U.S. Universities and "Millo Blanco", a local cultivar, was established at the Isabela Substation on a Coto clay (Oxisol). A split-plot experimental design with four replications, was followed, where the grasses were the main plots and three seeding rates, the sub-plots. The seeding rates were 20, 30 and 40 pounds of seed per acre. The plots were harvested 8 times at 45-day intervals. Data on protein, and green and dry forage were recorded (Appendix 17). There were significant differences in green forage between hybrids but not between seeding rates. Hybrid SX-16 produced the highest green forage yield per hectare, significantly different from all other hybrids. However, there were no significant differences in dry forage yield among SX-16, Pioneer 988, SX-17, FFR 66, and Sordan 80. Hybrids SX-16 and Pioneer 988 were significantly different in dry forage yield from FFR 74, SX-15, Trudan-6 and the local cultivar "Millo Blanco", and both were significantly different in crude protein from all the other entries.

A similar experiment was conducted in an Ultisol and data are presented on Appendix 18. There was no seed available of hybrids FFR 66 and FFR 74 and were, therefore, not included. Grazer A, a hybrid from Asgrow was included. The hybrids in this experiment followed the same trend as in the one before, being SX-16, Grazer A, SX-17, Sordan 80 and Pioneer 988 the best yielders. Only six cuttings were possible in this test. After the sixth harvest the stands of all the hybrids but SX-16 and Grazer A were so poor that the experiment was discontinued. Some of the data are not analyzed as yet but differences between hybrids apparently exist.

B - Agronomic evaluations of eleven sorghum x sorghum forage hybrids and "Millo Blanco" in two locations.

Eleven sorghum x sorghum forage hybrids were evaluated for green and dry forage and protein yield at two locations using a randomized-blocks experimental design with four replications. The sites were the Isabela (Oxisol) and Corozal (Ultisol) Agricultural Experiment Substations. Hybrid Grazer A was used at Corozal instead of FS 25 a. These experiments were planted at different dates. The experiment at Isabela was harvested eight times and only seven at Corozal.

Green forage yield was not significantly different between hybrids at Isabela, however, there were significant differences among hybrids in dry forage yield (Appendix 19). The range in production per hectare varied from 41.39 to 29.45 ton of dry forage with crude protein varying from 3.77 to 2.86 ton/ha. At the Corozal Substation significant differences between hybrids were found in green forage as well as in dry forage yields. Hybrids Pioneer 979, NK 318 s, and NK 367 were among the top producers at both locations. Hybrid Grazer A performed very well at the Corozal Substation. It is interesting to note that "Millo Blanco", the local cultivar, performed quite well at both locations. (Appendix 20)

Operational significance

Similar work performed under this project is underway at the Universities of Texas, Kansas and Mississippi. The International Centers in India (ICRISAT) and Mexico (CIMMYT) and other tropical countries are also doing research on sorghum to obtain high yielding cultivars with resistance to insect and diseases and with wide adaptability.

It has been found that sorghum pests are common and similar in all sorghum producing areas. Anthracnose, smuts, leaf blight (Helminthosporium) and zonate leaf blight are diseases reported everywhere sorghum is grown. The same is true with insect pests. The sorghum webworm, sorghum midge, fall armyworm, and corn earworm are good examples.

Side Effects of the Work

The research has not produced any information as yet that may be used to measure side effects. The findings to date do not suggest unexpected complications for the application of the same.

Research design

No significant modifications were made in the research design during the current reporting period. Research findings do not suggest a new approach.

Dissemination and Utilization of Research Results

Since this is a relatively new project no publications are available as yet. However, data are already being accumulated and will soon be available to interested institutions and individuals. Most LDC's programs have already been contacted and request for information and material have been received from El Salvador, Nicaragua and Ecuador.

Since the main objective of this project is to help in increasing sorghum production in LDC's the project participants believed that activities involving these countries should be enhanced. Join activities as field work, visit exchange and others are needed. Limited funds have impeded these activities during the current reporting period.

Work Plan for the coming year

1. Field tests will be established for the screening of improved lines and strains for other breeding programs to develop and identify superior types adapted to tropical conditions.

2. Sorghum lines from the temperate-tropical conversion program will be evaluated for yield, growth habit, and resistance to diseases, insects and nematodes.

3. Selected lines from the All Disease Nursery will be grown for further evaluation and seed increase.

4. A sorghum population using a male-sterility factor and selected lines from the Texas conversion program will be developed.

5. Seed-borne diseases will be studied, with special reference to their effects on germination and keeping quality of sorghum grain in storage.

6. Effects of pre-emergence and post-emergence herbicides on various sorghum genotypes will be evaluated under Puerto Rican conditions.

Budget 1976-77

Category	
Salaries and wages	$52,574.00
Overhead	29,447.00
Fringe Benefits	4,038.00
Supplies and Materials	3,201.00
Equipment	3,240.00
Printing and Binding	500.00
Travel and Transportation	7,000.00
Total	$100,000.00

Official Trips

1- Second Crop Division Contractor's Meeting. Lincoln - Nebraska September - 1975

The purpose of this meeting was to review the sorghum projects under AID contracts underway in the different universities.

Appendix 1. Foliar disease ratings of converted sorghum lines, Lajas spring 1976. Readings on mature plants made May 19, 1976. Zummo scale in gradations of 0.5 units.

Designation	Helminth.	Anthrac.	Rust	Designation	Helminth.	Anthrac.	Rust
IS 530C	3	3	2.5	IS 5394C	3.5	3	3.5
IS 1047C	3.5	3	3	IS 5530C	5	4.5	4
IS 1121C	3.5	2.5	2	IS 5554C	4	3.5	5
IS 113C	4.5	3	3.5	IS 5747C	3.5	3	4
IS 1134C	3	2.5	2	IS 5769C	4	3	4.5
IS 1139C	4	2	4	IS 5887C	4	3	3
IS 1140C	3.5	3	4	IS 5892C	4	3	4
IS 1141C	4.5	3	4	IS 6271C	3	3	3
IS 1143C	4	3	3.5	IS 6389C	3	3	3.5
IS 1151C	4	2.5	3	IS 6418C	4	2.5	3
IS 1159C	3	3	2	IS 6439C	4	3	3
IS 1166C	3.5	2.5	3	IS 6440C	4	2.5	2.5
IS 1207C	3.5	2.5	1	IS 6456C	3.5	3.5	3.5
IS 1309C	3	3	3.5	IS 6710C	3	3.5	4
IS 1335C	3	3	2.5	IS 6845C	2	4	2.5
IS 1526C	3.5	3	4	IS 6882C	3	3	4
IS 2169C	3.5	4	3.5	IS 6895C	3	3	4
IS 2177C	3.5	3.5	4	IS 6906C	missing row		
IS 2198C	4	3	4	IS 6964C	3	3.5	4
IS 2246C	3.5	2	1	IS 7044C	4.5	1	2
IS 2477C	4	4	3.5	IS 7094C	4	3	3.5
IS 2478C	3.5	3	3	IS 7173C	3	4	3.5
IS 2501C	3	3.5	3	IS 7242C	3	3.5	4
IS 2508C	3	3	4	IS 7254C	3	3	3
IS 2662C	3.5	3	3.5	IS 7340C	3.5	3	3.5
IS 2757C	3	3	3	IS 7367C	3.5	3	3
IS 3071C	3	3	4	IS 7379C	3.5	4.5	2.5
IS 3464C	4	3	3	IS 7440C	3.5	4	1
IS 3477C	2.5	3	2.5	IS 7444C	4	4	4
IS 3574C	2.5	2.5	2.5	IS 7447C	3.5	3	2.5
IS 3612C	4	3	2	IS 7452C	3	3	3
IS 3620C	3.5	3	5	IS 7518C	2.5	4	3.5
IS 3625C	3	2.5	3	IS 7524C	3.5	3	3
IS 3627C	3.5	3	4	IS 7535C	3.5	3	3.5
IS 3814C	3.5	3	3.5	IS 7537C	missing row		
IS 3911C	4	3.5	2.5	IS 7541C	3.5	2.5	1
IS 3955C	3.5	2	2	IS 7542C	2.5	3.5	3
IS 3956C	4.5	2	3	IS 7543C	3.5	3.5	3.5

Appendix 1. (Cont.)

Designation	Helminth.	Anthrac.	Rust	Designation	Helminth.	Anthrac.	Rust
IS 4839C	4	3	4	IS 7596C	3	2.5	3.5
IS 4884C	3.5	4	3.5	IS 7612C	2.5	3	3
IS 7617C	3.5	4	4.5	IS 12563C	4	3.5	2.5
IS 7735C	3.5	3	4	IS 12564C	3.5	3.5	3
IS 7738C	4	3	3	IS 12568C	3.5	3	4.5
IS 7762C	3.5	4	4	IS 12570C	3.5	3.5	4
IS 7769C	3.5	2	3	IS 12573C	2.5	2.5	3
IS 7776C	2	3.5	1	IS 12575C	3	3	4
IS 7778C	3	4	3	IS 12587C	3.5	3.5	3
IS 7787C	4.5	4	3	IS 12588C	2.5	3.5	3
IS 7790C	3	4	4	IS 12599C	3	4	4
IS 7809C	3	3	2.5	IS 12602C	3	3	2.5
IS 7864C	3.5	4	4	IS 12612C	3.5	2.5	4
IS 7907C	3.5	3.5	4	IS 12615C	3.5	3.5	3
IS 8052C	5	3.5	4	IS 12618C	4	3	2
IS 8100C	3	3.5	3.5	IS 12635C	5	3	3
IS 12526C	4.5	3.5	3	IS 12638C	3	2	2
IS 12537C	4	1	2	IS 12656C	2.5	2.5	2.5
IS 12539C	4	2.5	2	IS 12657C	3.5	3	2.5
IS 12549C	3.5	3.5	3.5	IS 12658C	3.5	3	2
IS 12551C	4	2	3.5	IS 12680C	3.5	3.5	4
IS 12556C	3.5	2	3	IS 12685C	3.5	2	3

The following scale, developed by Dr. Nat Zummo for the All-Disease Nursery was used:

0 = disease absent
1 = resistant
2 = disease inconspicuous or present on an occasional plant
3 = disease abundant (over 50% prevalence with low severity; apparently causing little economic damage)
4 = disease severe (100% prevalent, estimated leaf area destroyed up to 25%; disease appears to be of economic importance)
5 = as in 4 but over 25% of leaf area destroyed

Note: There is a natural tendency to under-rate disease incidence in tan varieties because lesions lack colored borders.

Appendix 2. - Foliar disease evaluation of converted lines of 11/8/75 at Isabela, Puerto Rico. 1/

Designation	Helminth.	Anthrac.	Rust	Zonate leaf spot
IS 530C	0	0	1	2
IS 1047C	1	0	1	2
IS 1121C	0	0	1	2
IS 1133C	0	0	0	3
IS 1134C	0	0	1	2
IS 1139C	0	1	2	2
IS 1140C	0	1	2	3
IS 1141C	1	4	2	3
IS 1143C	0	2	1	3
IS 1151C	1	3	3	2
IS 1159C	1	0	1	1
IS 1166C	0	0	1	1
IS 1207C	0	0	1	2
IS 1309C	0	0	1	2
IS 1335C	0	0	1	1
IS 1526C	0	1	2	2
IS 2169C	2	1	0	2
IS 2177C	0	1	2	3
IS 2198C	1	1	2	2
IS 2246C	1	0	2	1
IS 2477C	0	0	1	2
IS 2478C	0	0	1	3
IS 2501C	0	0	1	3
IS 2508C	0	0	0	1
IS 2662C	0	0	1	2
IS 2757C	0	0	1	2
IS 3071C	0	0	0	1
IS 3464C	0	0	1	2
IS 3477C	0	0	2	2
IS 3574C	0	0	2	2
IS 3612C	0	0	1	2
IS 3620C	0	0	2	2
IS 3625C	0	0	1	3
IS 3627C	0	0	2	3
IS 3814C	0	0	2	2
IS 3911C	0	0	2	2
IS 3955C	0	0	2	2
IS 3956C	0	0	2	2
IS 4839C	0	0	3	2
IS 4884C	0	0	3	2
IS 5394C	0	1	2	2
IS 5530C	0	2	2	2
IS 5554C	0	0	2	2
IS 5747C	0	0	2	2

Appendix 2. (Cont.)

Designation	Helminth.	Anthrac.	Rust	Zonate leaf spot
IS 5769C	0	0	2	2
IS 5887C	2	0	2	2
IS 5892C	0	0	1	2
IS 6271C	0	0	2	2
IS 6389C	0	0	2	2
IS 6418C	0	0	0	2
IS 6440C	0	0	1	2
IS 6456C	0	0	1	3
IS 6710C	0	0	2	3
IS 6845C	0	0	1	3
IS 6882C	0	0	0	2
IS 6895C	0	0	1	3
IS 6906C	0	0	1	2
IS 6964C	0	0	1	2
IS 7044C	2	1	1	2
IS 7094C	0	0	1	2
IS 7173C	0	0	1	1
IS 7242C	0	0	2	3
IS 7254C	0	0	1	2
IS 7340C	1	0	1	3
IS 7367C	0	0	1	2
IS 7369C	1	0	1	2
IS 7440C	0	0	0	2
IS 7444C	0	0	2	2
IS 7447C	0	0	1	1
IS 7452C	0	0	1	1
IS 7518C	0	0	1	3
IS 7524C	0	0	2	2
IS 7535C	0	0	1	2
IS 7537C	0	0	2	2
IS 7541C	0	0	0	2
IS 7542C	0	0	1	2
IS 7543C	1	0	1	1
IS 7596C	0	0	1	2
IS 7612C	0	0	1	1
IS 7617C	0	0	1	2
IS 7735C	0	0	2	3
IS 7738C	0	0	1	2
IS 7762C	0	0	2	3
IS 7769C	0	0	2	2
IS 7776C	0	0	1	2
IS 7778C	0	0	1	2
IS 7787C	1	0	1	1
IS 7790C	0	0	1	2
IS 7809C	0	0	1	1
IS 7864C	0	0	2	2

Appendix 2. (Cont.)

Designation	Helminth.	Anthrac.	Rust	Zonate leaf spot
IS 7907C	0	0	2	2
IS 8052C	0	0	2	2
IS 8100C	0	0	2	2
IS 12526C	0	0	2	2
IS 12537C	0	0	1	2
IS 12539C	0	0	0	2
IS 12540C	0	0	2	3
IS 12551C	0	0	2	2
IS 12556C	0	0	2	2
IS 12563C	0	0	0	2
IS 12564C	0	0	0	1
IS 12568C	0	0	2	3
IS 12570C	0	0	2	3
IS 12573C	0	0	2	3
IS 12575C	0	0	2	2
IS 12587C	0	0	1	1
IS 12588C	0	0	1	2
IS 12599C	0	0	1	1
IS 12602C	0	0	2	1
IS 12612C	0	0	1	1
IS 12615C	0	0	0	2
IS 12618C	0	0	2	2
IS 12635C	0	0	1	3
IS 12638C	0	0	1	2
IS 12656C	0	0	1	2
IS 12657C	0	0	2	2
IS 12658C	0	0	2	1
IS 12680C	0	0	2	3
IS 12685C	0	0	1	1

1/ A 0-4 rating scale used, 4 being the most susceptible.

Appendix 3. - Foliar disease ratings of 1975- All Disease Nursery, Lajas, Spring 1976. Reading made on May 19, 1976 on mature plants.

Entry No.	Designation	Helminth.	Anthrac.	Rust
1	SC 56-14	3.5	3.5	4
2	SC 89-9	3.5	3.5	2
3	97-14	missing		
4	103-12	4	3	3
5	108-14	3.5	3	3
6	109-12	3	4	3
7	Tam 428 (110-9)	3.5	2.5	2
8	SC 110-14	3	2	2.5
9	111-9	3	2	2.5
10	112-14 No UC	3	3	4
11	112-14 UC	3.5	3.5	1
12	115-11 E-1	3.5	2	2.5
13	120-14-1	2	2	3
14	170-6-8-3	3	2.5	2
15	170-6-8-8	4	2.5	3.5
16	170-6-17	4	2	2
17	170-14 E-3	3	2	3
18	173-12-6	4	2	2
19	Tam 2566	3.5	3	1
20	SC 175-14	2.5	3.5	1
21	228-14	4	3	1
22	237-14	3	3	4
23	239-14	3	2	1
24	279-14	3.5	3.5	1
25	324-12-2	2.5	2	4
26	325-12-P1	3	2.5	3.5
27	326-6	4	3	1
28	330-9-P1	3	3	2
29	333-14	3	4	3
30	334-9-P1	2.5	2	2.5
31	414-12 E-P1	3	3.5	2
32	420-12	3.5	3	4
33	423-14 (2680)	3.5	2	4
34	423-14 (2686)	3	3	4
35	546-14	3.5	3	3
36	574-6-P1	3.5	4	2.5
37	599-6-3 (9254)	4	3	3
38	599-6-3 (9245)	4	3	2
39	599-6-3 (9247)	3	3.5	1
40	599-6-10 (9188)	3.5	3	1
41	599-6-10 (9193)	3	3.5	1
42	599-11 E	missing		
43	680-3-2	3.5	3	3
44	748-5-3	3.5	3	3.5
45	SC 167-14	3	3	2
46	NSA 440-12	4	2	4

Appendix 3. - (Cont.)

Entry No.	Designation	Helminth.	Anthrac.	Rust
47	817-3	3	2	2.5
48	837-1	3	3	3
49	935-6	2	2	2
50	Q L 3 (sel)	3	2	4.5
51	B3197 x 170-6(1750)	3	3	2
52	B3197 x 170-6(1753)	2.5	0	1
53	SC 110-9 x SC 120-6	3	2	2.5
54	SC 599-6 x SC 134	3	3.5	1
55	SC 120-6 x Tx 7000	3	1	4
56	IS 2930 x IS 3922	3	2	1
57	SC 56 x SC 170(1584)	3.5	3.5	4.5
58	SC 56 x SC 170(1922)	3	3	2
59	SC 56 x SC 33(1778)	3	3	2
60	B 406 x Rio	3.5	2	1
61	TAM 2567	3	2.5	2.5
62	Tx 2536 x 170-6-5-1 E 2	3	3.5	3
63	SC 599-6 x 110-P1-1-1-1	3.5	2.5	1
64	B 3197 x SC 170	3	3	2.5
65	Tx 2536	3	3	3
66	Tx 09	4	3	4
67	Tx 7078	3	2.5	5
68	B Tx 398	3.5	2.5	4.5
69	B Tx 378	3	2.5	3.5
70	Sweet Sudan	4	2	3.5

Appendix 4. Foliar disease ratings of the 1975 All Disease Nursery at Isabela, Puerto Rico. Reading made on December 17, 1975. 1/

Entry No.	Designation	Helminth.	Anthrac.	Rust	Cleoc.
1	SC 56-14	0	0	3	3
2	SC 89-9	1	0	2	2
3	97-14	0	0	2	2
4	103-12	2	0	2.5	3
5	108-14	0	0	2	2
6	109-12	0	3	2	2.5
7	TAM 428	0	0	2	2
8	SC 110-14	0	0	2	1.5
9	111-9	0	1	2	2
10	112-14 (NO UC)	0.5	0	3	2
11	112-14 (UC)	0	0.5	1	1
12	115-11E-1	0	1	2	2
13	120-14-1	0	0.5	1.5	2
14	170-6-8-3	0.5	1.5	3	2
15	170-6-8-8	0.5	2	2	2
16	170-6-17	1.5	2.5	2	2
17	170-14E-3	0.5	1	3	2
18	173-12-6	2	0	2	2
19	TAM 2566	0.5	2	2	2
20	SC 175-14	0.5	1.5	1	1
21	228-14	1.5	0	2	2
22	237-14	0	0	2.5	2
23	239-14	0	0	2	2
24	279-14	0	0	2	2
25	324-12-2	0	0	3	2.5
26	325-12-pl.	0	2	3	2
27	326-6	0.5	0	0.5	1
28	330-9-pl.	0.5	0	2.5	2
29	333-14	0	2	2	2
30	334-9-pl.	0	0	2	1
31	414-12E-pl.	0.5	0	2	2
32	420-12	0	1.5	2.5	2
33	423-14 (2680)	0	0	2.5	2
34	423-14 (2686)	0	1	2	2
35	546-14	0	1	2	3
36	574-6-pl.	0	0	2	2
37	599-6-3 (9054)	2	2.5	2	2
38	599-6-3- (9245)	0.5	0	1.5	2
39	599-6-3- (9247)	0	0	1	1
40	599-6-10 (9188)	0	0	1	1.5
41	599-6-10 (9193)	0	0	2	2
42	599-11E	1	0	1	2
43	680-3-2	0	0	2	2
44	748-5-3	0	0	2	2

Appendix 4 (Cont.)

Entry No.	Designation	Helminth.	Anthrac.	Rust	Gleoc.
45	SC 167-14	0.5	0	2.5	2.5
46	NSA 440-12	0	0	2.5	3
47	817-3	0	0	2.5	2
48	837-1	0	0	2	2
49	935-6	0	0.5	1.5	2
50	QL 3(sel)	0	0	3	2.5
51	B 3197 x 170-6 (1750)	1	2	2	2
52	B 3197 x 170-6 (1753)	0.5	2	2	2
53	SC 110-9 x SC 120-6	0	0	2.5	2
54	SC 599-6 x SC 134	0	1.5	1.5	1.5
55	SC 120-6 x Tx 7000	0	0	2	2
56	IS 2930 x IS 3922	1	0	2	2
57	SC 56 x SC 170 (1584)	0.5	2.5	3	2.5
58	SC 56 x SC 170 (1922)	0.5	2	3.5	3
59	SC 56 x SC 33	0	0	3	2
60	(B 406 x Rio)-2	1	0	2	2
61	TAM 2567	0	0	2	2
62	Tx 2536 x 170-6-5-1-E2	0	1	2	2
63	SC 599-6 x 110-p1-1-1	Missing			
64	B 3197 x SC 170	0.5	0	2	2
65	Tx 2536	0	0	2	2
66	Tx 09	0	0	3	3
67	Tx 7078	0	1	3	3
68	BTx 398	0	1.5	3.5	2.5
69	BTx 378	0	0	3	2
70	Sweet sudan	3	0	3	1.5

1/ A 0-4 rating scale used in degree of severity. 4 the most severe. The readings at Isabela and Lajas were made by x different persons.

Appendix 5. - Foliar disease ratings of sorghum lines included in bulk population PR-2 at Isabela-MITA, spring 1976. Readings on mature plants April 23, 1976.

Designation	Anthrac.	Helminth.	Rust	Designation	Anthrac.	Helminth	Rust
IS 3620C	5	4	5	ADN 144	5	3	4
IS 7173C	3	4	4	ADN 154	3	3	3
IS 12569C	3	5	5	ADN 265	4	4	4
TAM Bk45	4	4	4	ADN 101	2	4	3
SC 1030-5	4	4	5	SC 0326-6	4	4	1
IS 7452	4	4	4	ADN 168	3	4	5
IS 30710C	3	4	4	ADN 116	3	3	4
ADN 142	2	3	4	ADN 265	3	3	3
SC 0599-6-3	3	2	4	ADN 121	2	4	3
ADN 155	3	3	4	ADN 252	3	4	4
74T190-2	3	3	3	SC 1030-5	3	3	3
IS 1335C	3	3	3	ADN 228	3	2	2
IS 10542	2	4	4	IS 12556C	3	3	2
TAM 428	3	4	3	IS 6906C	3	3	2
TAM 2566	3	2	3	IS 12539C	2	4	1
IS 3579C	4	3	2	IS 7254C	3	3	3
				IS 6882C	2	3	1

Summary: Lines showing immunity or field resistance: Antra. ADN 143, IS 10542, ADN 101, ADN 121, IS 12539C, IS 6882C; Rust SC 0326-6, IS 12539C, IS 6882C; Helminth. SC 0599-6-3, TAM 2566, ADN 288. Line showing good balanced resistance to all three diseases: IS 6882C, ADN 288, IS 12556C, IS 6906C, TAM 2566.

Appendix 6. Foliar Disease ratings of Dr. Fred Miller selections, Isabela, spring 1976. Read April 23 (1. approx. 1/2 bloom) and May 27 (2. approx. physiological maturity). Average of four replications. Range given in parenthesis when greater than 1 unit. 1/

Designation	Antracnose		Rust		Helminthosporium		Bacterial Stripe	
	1	2	1	2	1	2	1	2
ADN 250	3	1	0	3.25(2-4)	2.5	3.75	0	0
ADN 232	2.5	3.75	0	2.5	2	3	2	4
IS 1335C	2	3	0	3	0	4	2	3
IS 12526C	2	3	2	3.25	0	3.75	2	2.5
TAM 2566	2	3.25	0	3	2	3	2	3.5
SC 175-14E	2.5	3.5	0	2.25(1-3)	3	3.25	2	4
ADN 155	0	2 (1-3)	0	2.5	2	3.25	0	0
ADN 156	0	2.5	0	3.75	2	2.5	0	0
SC 175-679-2	2	4	0	2.75	2	3	2	3.5
SC 112C	2	3	0	4	0	3.75	0	2.5
Centa S-1	2	2.15	2	4.5	2	4.25	0	2
Redland X ADN 156	2	2.5	2	3(2-4)	0	3(2-4)	0	2
NK 233	2	2.75 (2-4)	2	5	2	3.75	0	3

1/ Dr. Zummo rating scale used

Appendix 7. Rust infection in Isabela, P. R., on lines reported before as being highly resistant to *Puccinia purpurea*[1/]

Date of planting: October 30, 1975. Date of observations: a) Jan. 29, 1976
April 5, 1976

IS No.	PR No.	Disease index[2/] (a)	(b)	IS No.	PR No.	Disease index[2/] (a)	(b)
2651	10457	1 (late)	3	7751	67I3140	6	6
2678	10465	6	6	2549	66I3437	1	2
2704	10471	6	6	6956	66I3448	2	4
2736	66I1965	1	4	2	66I1108	6	6
2739	66I3235	3	6	3566	67I3450	6	6
3137	66I2165	3	6	3574	67I3443	6	6
9496	66I6800	5	6	3579	67I3456	0;	2
2615	66I1003	3	5	3727	67I3627	4	6
6842	66I1818	2	4	2990	67I4727	1	3
6919	67I3344	0	2	2991	66I4728	0,	3
3515	66I2496	1	3	910	66I4766	1	3
1318	66I2503	2	5				
3758	66I2459	0;	2				
7017	66I2710	6	6				
6992	66I2920	1	3				

1/ Miller, F. R. 1965-67. Annual Reports, Sorghum Project, Federal Experiment Station, USDA, Mayaguez, Puerto Rico, and Berquist, R. R. 1971. Sources of resistance in sorghum to *Puccinia purpurea* in Hawaii. Plant Disease Reporter 55:942-944.

2/ In order of severity 0-6, read by F. Miller and R. Alconero on January 20, and by R. Alconero on April 5.

Appendix 8. Preliminary evaluation of sorghum lines for the attacks of the fall armyworm, Spodoptera frugiperda and the sorghum webworm, Isabela Substation April-June, 1976

Cultivar	Fall army-worm damage index 1/	Sorghum web-worm damage index 1/
Redlands x ADN 156	1	2.8
NK-233	1.3	2.2
ADN 155	1.3	1.8
SC 112C	1.5	4.3
IS 12526C	1.5	3.5
SC 175-14E	1.8	4.7
TAM 2566	1.9	4.0
ADN 250	2.0	2.3
ADN 232	2.0	4.5
ADN 156	2.0	2.4
SC 175 679-2	2.3	5.0
Centa S-1	2.3	4.2
IS 1335C	2.8	3.0

1/ Based on visual inspection of the plants in 4 replicates; 1 to 5, 1 represent the damage free plants and 5 the most affected

Appendix 9. Preliminary evaluation of sorghum lines for the attack of the fall armyworm, *Spodoptera frugiperda*, and the sugarcane borer *Diatraea saccharalis*, Isabela Substation - November-January, 1976

Designation	Spodoptera Infested Plant 1/	Spodoptera Damage Index 2/	Diatraea Infested Stems 3/	Designation	Spodoptera Infested Plant 1/	Spodoptera Damage Index 2/	Diatraea Infested Stems 3/
IS 2246C	0	1	-	IS 1159C	0	1	1
IS 7447C	0	1	1	IS 530C	0	1	0
IS 12685C	0	1	2	IS 1151C	5	2	4
IS 12680C	0	1	3	IS 4884C	6	2	4
IS 3464C	0	1	3	IS 7048C	5	2	5
IS 3956C	0	1	3	IS 7612C	3	2	3
IS 12657C	0	1	2	IS 7809C	2	2	3
IS 12581C	0	1	3	IS 12662C	2	2	3
IS 12539C	0	1	4	IS 12599C	9	2	2
IS 7778C	0	1	3	IS 7790C	2	2	3
IS 7379C	0	1	3	IS 7596C	5		2
IS 6895C	0	1	3	IS 7444C	1	2	4
IS 5892C	0	1	3	IS 3477C	6	2	5
IS 3911C	0	1	3	IS 2198C	7	2	3
IS 6882C	0	1	1	IS 6271C	3	2	3
IS 7541C	0	1	0	IS 6906C	2	2	5
IS 7776C	0	1	0	IS 7440C	1	2	2
IS 12656C	0	1	3	IS 7543C	2	2	3
IS 12573C	0	1	1	IS 7787C	1	2	5
IS 7340C	0	1	1	IS 12588C	3	2	5
IS 7769C	0	1	4	IS 12558C	1	2	-
IS 7537C	0	1	3	IS 7542C	2	2	4
IS 6845C	0	1	2	IS 3955C	1	2	3
IS 5769C	0	1	4	IS 3071C	2	2	4
IS 7585C	0	1	2	IS 5887C	4	2	3
IS 7762C	0	1	2	IS 7367C	1	2	0
IS 8100C	0	1	3	IS 12575C	1	2	3
IS 12635C	0	1	2	IS 12638C	2	2	2
IS 12618C	0	1	1	IS 12526C	1	2	0
IS 8052C	0	1	5	IS 3814C	6	2	2
IS 7738C	0	1	2	IS 2662C	1	2	5
IS 7524C	0	1	2	IS 1335C	1	2	3
IS 5554C	0	1	3	IS 1133C	5	2	1
IS 3625C	0	1	0	IS 1309C	2	2	2
IS 2501C	0	1	1	IS 2508C	1	2	2
IS 1160C	0	1	0	IS 3627C	1	2	-
IS 7518C	0	1	2	IS 5747C	2	2	3
IS 7907C	0	1	1	IS 6710C	2	2	2
IS 12564C	0	1	1	IS 7254C	4	2	3
IS 7864C	0	1	2	IS 12570C	1	2	4
IS 7617C	0	1	2	IS 12568C	2	2	1
IS 7452C	0	1	3	IS 7273C	1	2	2
IS 7094C	0	1	3	IS 6456C	1	2	4
IS 6439C	0	1	1	IS 1207C	1	2	-
IS 3612C	0	1	1	IS 1121C	2	2	0
IS 2477C	0	1	3	IS 1047C	2	2	0

Appendix 9. (Cont.)

Designation	Spodoptera Infested Plant 1/	Spodoptera Damage Index 2/	Diatraea Infested Stems 3/	Designation	Spodoptera Infested Plant 1/	Spodoptera Damage Index 2/	Diatraea Infested Stems 3/
IS 3620C	4	2	2	IS 12549C	5	3	4
IS 5530C	4	2	4	IS 2177C	9	3	2
IS 7173C	1	2	3	IS 1141C	5	3	5
IS 12615C	3	2	2	IS 1143C	11	3	4
IS 12612C	3	2	1	IS 4839C	10	3	3
IS 5394C	5	3	3	IS 6389C	4	3	3
IS 2478C	6	3	3	IS 6418C	5	3	3
IS 1134C	9	3	1	IS 1526C	8	4	2
IS 12537C	8	3	0	IS 12551C	16	5	4
IS 1139C	6	3	2	IS 2757C	15	5	3
IS 1140C	9	3	2	IS 6440C	14	5	0
IS 2169C	4	3	1	IS 12556C	19	5	2

1/ Counts on 10 ft. row
2/ A 1-5 rating scale used (1 less infestation)
3/ A sample of 5 stems per line

Appendix 10. Phytoparasitic nematodes and suspected parasites from soil around roots of sorghum (*Sorghum bicolor*) and average populations from 15 samples of 250 cc from each locality.

Genera and Species	LOCALITY AND POPULATIONS/250 cc SOIL			
	Mayaguez	Lajas	Fortuna	Isabela
Pratylenchus zeae	63	32	792	447
Helicotylenchus sp.	104	39	176	591
Aphelenchus sp.	63	80	248	368
Aphelenchoides sp.	80	8	32	32
T. crassycaudatus	32	464	56	0
Tylenchus sp.	279	56	48	48
Pseudhalenchus sp.	0	0	0	80
Psilenchus sp.	8	0	0	0
R. reniformis	15	176	0	0
Hemicriconemoides cocophillus	0	0	63	0
Dorylaimus sp.	0	15	0	0
Neotylenchus sp.	0	8m	0	C
Trophyurus sp.	0	8	0	0
Longidorus sp.	0	15	8	0
M. incognita	0	8	0	0
Nothotylenchus sp.	0	48	0	0
Tetylenchus sp.	0	0	63	0
Total	644	957	1486	1566

Appendix 11.— Phytoparasitic and suspected parasitic nematodes isolated from sorghum roots and percent of total populations from four localities.

Genera and Species	LOCALITY AND % OCCURRENCE			
	Mayaguez	Lajas	Fortuna	Isabela
Pratylenchus zeae	9.81	3.31	53.39	28.44
Helicotylenchus sp.	16.12	4.09	11.83	37.60
Aphelenchus sp.	9.81	8.35	16.68	23.38
Aphelenchoides sp.	12.38	0.79	2.12	2.00
T. crassycaudatus	4.91	48.66	3.74	0.00
Tylenchus sp.	43.46	5.83	3.24	3.53
Pseudhalenchus sp.	0.00	0.00	0.00	5.06
Psilenchus sp.	1.17	0.00	0.00	0.00
R. reniformis	2.34	18.43	0.00	0.00
H. cocophillus	0.00	0.00	4.25	0.00
Dorylaimus sp.	0.00	1.57	0.00	0.00
Neotylenchus sp.	0.00	0.79	0.00	0.00
Trophyurus sp.	0.00	0.79	0.00	0.00
Longidorus sp.	0.00	1.57	0.51	0.00
M. incognita	0.00	0.79	0.00	0.00
Nothotylenchus sp.	0.00	5.04	0.00	0.00
Tetylenchus sp.	0.00	0.00	4.25	0.00

Appendix 12. Incidence in percentage of the number of samples of sorghum taken from each locality, for each nematode species at four localities.

Genera and Species	INCIDENCE PER LOCALITY			
	Mayaguez 15	Lajas 15	Fortuna 15	Isabela 15
Pratylenchus zeae	20.00	13.33	86.67	80.00
Helicotylenchus sp.	33.33	13.33	46.67	93.33
Aphelenchus sp.	40.00	46.67	80.00	80.00
Aphelenchoides sp.	33.33	6.67	13.33	20.00
T. crassycaudatus	13.33	46.67	26.67	0.00
Tylenchus sp.	80.00	26.67	40.00	33.33
Pseudhalenchus sp.	0.00	0.00	0.00	53.33
Psilenchus sp.	6.67	0.00	0.00	0.00
R. reniformis	6.67	46.67	0.00	0.00
H. cocophilus	0.00	0.00	33.33	0.00
Dorylaimus sp.	0.00	6.67	0.00	0.00
Neotylenchus sp.	0.00	6.67	0.00	0.00
Trophyurus sp.	0.00	6.67	0.00	0.00
Longidorus sp.	0.00	6.67	6.67	0.00
M. incognita	0.00	6.67	0.00	0.00
Nothotylenchus sp.	0.00	33.33	0.00	0.00
Tetylenchus sp.	0.00	0.00	40.00	0.00

Appendix 13. Population levels, pH, air temperature and soil texture from the four localities.

Locality	pH[b]	Air Temperature °C	SOIL TEXTURE %			Populations[a]
			Sand	Lime	Clay	
Mayaguez	5.85	28.5	17.00	18.00	65.00	644
Lajas	4.47	26.1	28.00	22.00	50.00	957
Fortuna	7.26	26.9	40.56	27.56	31.88	1486
Isabela	4.41	25.3	20.56	19.56	59.88	1566

[a] Average number of phytoparasitic nematodes in 250cc of soil

[b] Average pH for the locality

Appendix 14. Average height, top and root fresh and dry weights and root necrosis index from experiment to study effect of *P. zeae* and combinations of this and four soil fungi on sorghum.

Treatments	Height (cm)	TOPS Fresh Weights (g)	TOPS Dry Weights (g)	ROOTS Fresh Weights (g)	ROOTS Dry Weights (g)	Necrosis index**
P. zeae - *Curvularia* spp.	128.2 a*	99.7 a*	25.1 c	30.50 d	2.6 a	0.8 cd
P. zeae - *F. moniliforme*	129.0 a	119.7 a	27.4 abc	32.25 cd	3.1 a	1.2 bcd
P. zeae - *R. solani*	127.4 a	108.3 a	27.5 abc	33.85 cd	3.2 a	2.2 abc
P. zeae - *Macrophomina* sp.	114.0 a	111.1 a	26.9 abc	35.60 bcd	3.3 a	1.0 bcd
F. moniliforme	129.6 a	147.9 a	26.4 bc	35.65 bcd	3.1 a	1.8 abc
R. solani	121.1 a	115.4 a	27.8 abc	37.80 bcd	3.0 a	1.6 bc
P. zeae	131.4 a	113.9 a	26.4 bc	39.20 abcd	3.9 a	3.2 a
Macrophomina sp.	130.1 a	104.0 a	28.1 abc	42.35 abc	3.8 a	1.6 bc
Curvularia spp.	125.5 a	121.1 a	28.9 ab	45.65 ab	3.7 a	2.4 ab
Control	135.6 a	128.1 a	29.7 a	49.25 a	6.0 b	0.0 d

* = Averages with the same letter are not significant according to Duncan's Multiple Range Test.

** = Index of necrosis based on classification of 0 (no necrosis) to 5 (intensive necrosis)

Appendix 15. Average height, fresh & dry weights of leaves, stems and roots and index of necrosis from experiment for the study of the effect of *P. zeae*, *F. moniliforme*, and *Curvularia* spp. alone and in different combinations on sorghum.

Treatments	Height (cm)	FOLIAR PARTS Fresh Weight (g)	FOLIAR PARTS Dry Weight (g)	ROOTS Fresh Weight (g)	ROOTS Dry Weight (g)	Necrosis Index **
P. zeae	24.26 b	22.40 b	10.80 a	4.32 bc	0.84 ab	2.2 abc
P. zeae - *F. moniliforme*	26.98 b	27.96 ab	11.74 a	3.90 c	0.53 b	2.6 abc
P. zeae - *Curvularia* sp.	24.60 b	24.46 ab	11.28 a	4.64 bc	0.86 ab	2.4 abc
P. zeae - *Curvularia* sp.- *F. moniliforme*	27.24 b	25.68 ab	11.40 a	6.92 ab	1.04 ab	3.4 a
F. moniliforme	32.38 a*	33.92 a	12.22 a	5.72 bc	0.55 b	1.6 bc
Curvularia sp.	26.02 b	23.54 ab	11.46 a	5.10 bc	0.78 ab	1.8 abc
Curvularia sp. *F. moniliforme*	28.44 ab	30.74 ab	11.90 a	8.76 a	1.09 ab	3.0 ab
Control	28.20 ab	21.52 b	10.90 a	7.02 ab	1.46 a	1.0 c

* = Averages with the same letter are not significant according to Duncan's Multiple Range Test.

** = Index of necrosis based on classification of 0 (no necrosis) to 5 (intensive necrosis).

Appendix 16. Sorghum weed control, panicle counts and foliage production[1/]

Treatment Kg a.i./ha		Weed Control 2/ Blvs. %	Grasses %	No Panicles above 11 cm long X 2 cm wide	Total No. 3/ Panicles	Green weight 4/ of plants kg/ha
1. Metribuzin	1.1	88.8 a	88.8 a	74 a	113 b	4606.7 ab
2. Bifenox	2.2	90.0 a	77.5 b	77 a	132 ab	4929.9 a
3. Velpar	2.2	86.2 a	81.2 b	54 a	75 c	2539.4 b
4. Linuron	3.4	91.2 a	88.8 a	83 a	134 ab	4372.6 ab
5. Atrazine	3.4	91.2 a	87.5 ab	74 a	143 ab	5397.1 a
6. Propazine	3.4	93.2 a	87.0 ab	80 a	134 ab	5058.0 a
7. Lin. + Prop.	1.1 + 2.2	89.5 a	86.2 ab	75 a	133 ab	5350.7 a
8. Atr. + Terb.	1.7 + 1.7	87.5 a	85.0 ab	82 a	168 a	5667.8 a
9. Hand-weeded		92.5 a	92.5 a	85 a	159 ab	5854.5 a
10. Non-weeded		--	--	68 a	151 ab	4360.4 ab

1/ Averages in vertical columns followed by the same letters are not significantly different at p= 0.05.
2/ Ratings based on visual observations, 3/25/76.
3/ Inferior sized panicles were included in total count although are not considered of commercial value.
4/ Plants were cut at ground level on 5/25/76.

Appendix 17. Agronomic evaluations of eight sudan grass-sorghum hybrids and "Millo Blanco" in an Oxisol in Puerto Rico. Total of 8-45 days interval cuttings

Entry	Source	Green Forage Ton/ha	Dry Matter %	Dry Forage Ton/ha	Crude Protein %	Crude Protein Ton/ha
SX-16	De Kalb	268.20 a	16.70	44.79 a	10.06	4.51 a
Pioneer 988	Pioneer	224.10 b	19.40	43.48 a	10.17	4.42 a
SX-17	De Kalb	221.91 b	17.55	38.95 abc	8.68	3.38 b
FFR 66	Purdue University	220.75 b	18.31	40.42 ab	8.77	3.54 b
Sordan-80	Northrup King	201.37 bc	19.16	38.58 abc	8.78	3.39 b
FFR 74	Purdue University	191.84 bcd	18.08	34.68 bcd	10.17	3.53 b
"Millo Blanco"	P.R.	191.63 bcd	15.69	30.07 d	10.00	3.01 b
SX-15	De Kalb	170.21 cd	19.48	33.16 cd	9.54	3.16 b
Trudan-6	Northrup King	151.25 d	20.62	31.19 d	9.52	2.97 b

Appendix 18. Agronomic evaluations of seven sorghum X sudan grass hybrids and "Millo Blanco" in an Ultisol in Puerto Rico. Total of 6-45 days interval cuttings.

Entry	Source	Green Forage Ton/ha	Dry Matter %	Dry Forage Ton/ha	Crude Protein %	Crude Protein Ton/ha
SX-16	De Kalb	127.01	15.58	19.79	10.09	2.00
Grazer A	Asgrow	124.86	15.45	19.29	10.68	2.06
SX-17	De Kalb	115.83	15.64	18.12	10.97	1.99
Sordan 80	Northrup King	110.78	16.80	18.61	10.28	1.91
Pioneer 988	Pioneer	100.71	17.44	17.56	10.72	1.88
SX-15	De Kalb	86.45	18.41	15.92	11.35	1.80
Trudan-6	Northrup King	85.52	17.27	14.77	10.96	1.62
Millo Blanco	P.R.	82.35	15.95	13.13	12.17	1.60

Appendix 19. - Agronomic evaluations of eleven forage sorghum hybrids and "Millo Blanco", a local cultivar, in an Oxisol in Puerto Rico (Total yield data in eight cuttings - 45 day intervals).

Entry	Source	Green Forage Ton/ha	Dry Matter %	Dry Forage Ton/ha	Crude Protein %	Crude Protein Ton/ha
NK 367	Northrup King	224.20	17.30	38.79 ab	9.72	3.77
NK 318s	Northrup King	223.52	16.68	37.28 abc	9.38	3.50
979	Pioneer	220.97	18.73	41.39 a	8.22	3.40
F-S-4	De Kalb	207.46	17.86	37.05 abc	9.38	3.48
FS-16	De Kalb	203.00	16.48	33.45 abc	9.75	3.26
927	Pioneer	199.14	17.74	35.33 abc	9.19	3.25
931	Pioneer	193.88	19.75	38.29 ab	8.22	3.15
NK 300	Northrup King	190.78	18.39	35.08 abc	10.38	3.64
FS-24	De Kalb	190.74	16.06	30.63 bc	10.10	3.09
944	Pioneer	183.62	17.92	32.90 bc	10.82	3.56
FS-25a	De Kalb	182.79	18.03	32.96 bc	10.00	3.30
Millo Blanco	P.R.	182.49	16.14	29.45 c	9.72	2.86

Appendix 20. - Agronomic evaluations of eleven forage sorghum hybrids and "Millo Blanco", a local cultivar, in an Ultisol in Puerto Rico. (Total of 7-45 days interval cuttings)

Entry	Source	Green Forage Ton/ha	Dry Matter %	Dry Forage Ton/ha	Crude Protein %	Crude Protein Ton/ha
979	Pioneer	185.82 a	15.11	28.08 a	10.63	2.98
Grazer A	Asgrow	167.09 a	14.47	24.18 ab	11.82	2.86
NK 318 s	Northrup King	137.13 b	14.33	19.65 bcd	12.13	2.38
931	Pioneer	131.02 bc	16.64	21.80 bc	12.03	2.62
Millo Blanco	Puerto Rico	129.36 bcd	14.11	18.25 cd	12.10	2.21
NK 367	Northrup King	128.71 bcd	13.83	17.80 cde	12.38	2.20
FS-24	De Kalb	106.98 cd	15.86	16.97 cde	12.07	2.05
FS-4	De Kalb	106.36 cde	14.90	15.85 de	11.32	1.79
927	Pioneer	103.30 cde	15.31	15.82 de	12.41	1.96
NK 300	Northrup King	102.81 cde	16.58	17.05 cde	12.83	2.11
944	Pioneer	101.22 de	15.95	16.14 de	12.57	2.03
FS 16	De Kalb	88.27 e	14.74	13.01 e	12.07	1.57