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Termination Report

on

Development of Improved, High-Yielding Sorghum Cultivars

Contract No. AID/ta - C - 1087

June 1, 1976 - May 31, 1977

Prepared by:

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A - Summary

1- Project Title and Contract Number:

Development of Improved High-Yielding Sorghum Cultivars

Contract Number AID/ta-C-1087

2- Principal Investigators:

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

5- Reporting Period: June 1, 1976 to May 31, 1977

6- Total Expenditures and Obligations Through Previous Contract Years:

$ 114,700.00

7- Total Expenditures and Obligations for Current Contract Year:

$ 87,275.84

A race of the pathogen causing anthracnose was found on the cultivar TAM 428. This cultivar is resistant to the Texas strains. This show the importance of regional evaluations of germplasms. Different races of the different pathogens may occur in different geographical areas.

An association of rust and the Coniothyrium leaf spot was found. The Coniothyrium pathogen gains ingress in the leaf tissue only through rust pustules.

Our studies have shown the association of the bacterium Spirillum lipoferum Beijerinck with sorghum. This nitrogen fixing bacterium dominates the rhizoplane microflora, becomes systemic and is passed from one sorghum generation to another through the seed.

Grain quality is affected to some extent by seed borne pathogens. Field emergence is greatly affected by these pathogens. Harvesting at physiological maturity, sun-drying, treatment with Arasan, and storing in sealed polyethylene bags improve significantly the germination.

Nematodes, also, are very important pests in sorghum production. The most commonly encountered species in Puerto Rico are Pratylenchus zeae; Helicolytenchus sp.; Tylenchus sp.; Tylenchorhynchus sp.; Aphelenchus sp.; and Aphelenchoides sp. Resistant sorghum lines have been identified. Also, soil treatments with 44.96 Kg ia/ha. of carbofuran control very well the nematodes on sorghum.

Data on weed control showed that Metribuzin, Atrazine + Terbutrin; and Atrazine + Propachlor give good control of weeds on sorghum.

Yields on grain sorghum hybrids from a variety test ranged from 3,179.0 to 5,630 kg/ha. The hybrids Nk 233 and B815 were the best yielders.

Forage sorghum hybrids were evaluated at two locations. The best yielders were SX-16, SX-17, Grazer A, Pioneer 988, Pioneer 979, NK318s, and NK 367. Dry forage production ranged from 13 to 45 ton/ha/yr. with crude protein varying from 1.6 to 4.5 ton/ha./yr.

Eighty three lines selected from the Conversion Program, the All Disease Nursery and other breeding programs were crossed to material containing the genetic male sterile gene ms_3. A composite of the seed was planted at the Isabela Agricultural Experiment Station. Male sterile plants were tagged at bloom and harvested at maturity. Equal quantities of seed from the harvested plants were composited for a second cycle of random mating.

B - Project Objectives

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

C - Accomplishments to Date

Findings

I- Entomology

The insect pests attacking sorghum in Puerto Rico were determined as follows:

1.-	Webworm type	*Sathrota* sp.
2.-	The corn earworm	*Heliothis zea* (Fabricius)
3.-	The Fall Army worm	*Spodoptera frugiperda* (J. E. Smith)
4.-	The sugar cane borer	*Diatraea saccharalis* (Fabricius)
5.-	The lesser constalk borer	Elasmopalpus lignosellus (Zeller)
6.-	The corn aphids	*Rhopalosiphum maidis*

7.- The chinch bug *Blissus leucopterus* Say

8.- The sorghum midget *Contarinia sorghicola*

9.- Sucking insects, like scales and plant bugs

However, the most serious pest of sorghum in Puerto Rico were the birds. They caused the destruction of several experimental plots, making it mandatory the use of a nylon-mesh to cover the plot. The webworm is an unreported species as a sorghum pest in Puerto Rico. This is probably the second pest problem after the birds causing a considerable loss of grain while it is drying. The corn earworm is one of the most abundant insect in sorghum during the milk stage. Plant bugs have been found in all plantings, particularly, in plants with compact and closed heads. Damage of this insect has not been determined. The other insects mentioned were found commonly in the sorghum plants.

Several material (120 lines) from the sorghum convertion program were evaluated for insect attack. These lines were divided into 4 groups and planted throughout the year. Four cultivars were included for comparison in all plantings. All cultivars were planted in plots of one row of 10 feet 3 feet apart and arranged in a complete randomized block design with 4 replicates.

The results of all plantings are included on Tables 1-10. During September the attack of the fall armyworm was very low, with very little differences among the cultivars (Table 1). The corn earworm attack was heaviest in lines IS 1151C, IS 12556C and IS 2662C (Table 2). Attempts were made to determine the number of webworm larvae per head, however, infestation was not consistent. During December and January the infestation of the corn earworm and the sorghum webworm were very low (Tables 4, 5, 6). The corn earworm attack was heaviest during February. The following lines showed evidence of resistance: IS 8100C, IS 125-G3C, IS 7907C, IS 7596C, IS 7738 C, and IS 7044C (Table 7). The webworm damage was very low during February (Table 8), ans was heaviest

during March 1977 when most of the lines were heavily affected; being the following the less affected lines: IS 7907C, IS 7524C, IS 7612C and IS 7762, which were less affected (Table 9). Bird damage was also heaviest during March. Data were taken of thelines less affected by birds, such as: IS 7809C, IS 7173, IS 8100C, IS 12568C, IS 6440C, IS 2556C, IS 7094C and IS 12656 C (Table 9).

Two experiments were conducted to evaluate different chemicals for the control of insects and birds. The first experiment was planted on September 9, 1976, using the cultivar IS 1047C in the experimental plots and cultivar IS 1140C as border around the plots. A randomized complete block design was used with 4 replicates. Plots consisted of 3 rows of 10 x 3 feet and planting distance among plants was 4 inches. The material tested were as follows: 1) Lannate 1.8L at 2 pts/A., 2) Arazan 42S at 2 gals/A., 3) Mesurol at 3 lbs/A., 4) Furadan 4F at 2 pts/A., 5) Thiodan 2E at 2 pts/A., 6) Vydate 2L at 2 pts/A., 7) Sevin 80WP at 2.5 lb./A., 8) Dipel WP at 1 lb/A., 9) Diazinon AG-500 at 1 pt per acre and 10) check untreated. The first application was on November 7 and weekly thereafter until a week before harvesting. Results of these tests are presented in table 10. The best treatment for the webworm control was Lannate, following Arazan, Sevin and Thiodan. The rest of the treatments gave some control of this insect as compared with the control. Corn earworm damage was very low in all treatments. Lannate and Arazan were also the most effective for bird damage control. However, the effect on yield was not significant in any of the treatments with the exception of Vydate 2L, which decreased significantly when compared with the control, probably due to toxicity.

The second experiment was planted during January 1977 with the purpose to obtain more information on the most effective materials from the 1st test. However, the date at which treatments were made coincided with a rainy period affecting the effectiveness of the materials being evaluated.

II - Phytopathology

a) Leaf Blight (*Helminthosporium turcicum*) Resistance in Sorghum

The sporadic nature of leaf blight epiphytotics has hampered the evaluation of sorghum lines for resistance to this important disease. However, uniform natural spread of the disease in a fall planting of the 1976 All Disease and Insect Nursery (ADIN) at the Limani Substation provided very reliable resistance data; more than 70% of the lines exhibited severe symptoms (3-5 on the Zummo scale). Every resistant row was flanked by at least one severely affected row. Observations were made close to the physiological maturity stage of the majority of the lines. Identification of the disease was easy. No more than a trace of other foliar diseases was present at the time. Original inoculum came from an Isabela isolate of the pathogen grown on autoclaved sorghum seeds placed in the whorl of the first plant of each row, three weeks after planting. The following six, among the 70 entries, showed excellent resistance (ratings 2 on the Zummo scale, i.e. disease inconspicuous): 237-14, 239-14, 326-6, 574-6-PL, NSH935-6 and TAM 430 (Table 11).

Sources of resistance were found among those lines designated as Dobbs, Nigricans, YE-FET-der, Zerazera and some of their crosses. Zerazera material is, however, quite heterogeneous in this respect, with some lines being severely affected.

b) Effect of a Natural Anthracnose Epiphytotic on Yield, Grain Quality, and Seed Health in *Sorghum bicolor*.

An intense, naturally occurring anthracnose epiphytotic in a replicated field experiment including plots sprayed weekly with a benomyl-manzate mixture, provided conclusive data on the destructive potential of this disease. Fungicide treatment began soon after the appearance of the disease (boot stage) and yielded 53.8 gs./head and 24.0 gs/1000 seeds as compared to 16.2 gs/head and 14.2 gs/1000 seed weight for the nonsprayed control. Field emergence of seed from disease

free plots was 40% as compared to 14% for the anthracnose affected seed. These are the best yield loss data to date for this disease on grain sorghum grown in a humid tropical environment and indicate the devastating potential of a race of the pathogen not yet present in Texas. (TAM 428, used in the study, is resistant to Texas strains.

c) Coniothyrium Leaf Spot of Sorghum

The oval leaf spots caused Coniothyrium zeae Stout, first reported in 1976, have continued to increase in intensity with each successive planting at Mayaguez and Isabela. It was the most important foliar disease on several entries of the ADIN at Isabela in the winter of 1976-77, destroying as much as 25% of the leaf area. Diseased specimens showing similar symptoms collected by Dr. Richard Fredrickson in Poza Rica Tam. Mexico have confirmed the identity of the pathogen from the two countries.

Since the pathogen gains ingress only through rust pustules it will probably be of economic importance only in areas which experience early rust infection, however, its increasing severity in Puerto Rico suggests that it is a potentially dangerous disease and should be further studied.

d) Association of the Nitrogen Fixing Bacterium Spirillum lipoferum with Sorghum bicolor: an Advanced Symbiosis.

The nitrogen fixing bacterium Spirillum lipoferum Beijerinck is known to inhabit the roots and root surfaces of several tropical grasses. Our studies have shown the association of the bacterium with Sorghum bicolor to be a unique advanced type of symbiosis in which S. lipoferum dominates the rhizoplane microflora, becomes systemic and is passed from one Sorghum generation to another through the seed.

The excellent adaptation of S. lipoferum to growth on sorghum root surfaces was demonstrated by its natural occurrence on washed sorghum roots to the virtual exclusion of other bacteria and by its ability to multiply in situ 350 fold in 13 hours at room temperature. The systemic nature of the association was shown when the bacterium was recovered from surface sterilized stem pith tissue pieces taken

from randomly selected field grown plants in Mayaguez.

Approximately 80% of the surface sterilized seeds of TAM 428 produced at Isabela yielded S. lipoferum when treated with the fungicide benomyl. When seed from this lot was germinated in sterile sand vial cultures, the bacterium was readily recovered from the seedling root surfaces, thus proving seed transmission.

The association appears to be geographycally specific since neither TAM 428 seed from Texas nor that from the mountain station of Limaní carried the bacterium.

The percent of seed bearing the bacterium proved to be inversely related to grain yield when several sorghum lines were compared. It is clear then, that this new rather advanced type of symbiosis needs further basic research before it is rushed into agricultural application. (S. lipoferum have been isolated from a previously unreported host sugar-cane collected in five widely separated sites in Puerto Rico.)

e) Production and Storage of Sorghum seeds in a Tropical Environment.

A 6 level factorial experiment yielded the following general recommendations for the production and maintaince of high quality seeds: Harvest at physiological maturity then sun-dry before storing in sealed polyethylene bags. Treatment with Arasan significantly increases germination.

III - Nematology

In a greenhouse experiment, an initial inoculum consisting of 1,600 Pratylenchus zeae was enough to reduce the dry weight of 8-week old plants of the hybrid Dekalb E-57 of sorghum (Sorghum bicolor (L.) Moench) (Table 12.)

Another experiment was conducted at the MITA Farm at Isabela where the reaction of 10 grain varieties to a natural mixed phytoparasitic nematode

population was studied. At the end of a 3 month period and based on the study of different parameters of plants grown in soil treated with Fensulfothion and without treatment, the following results were obtained: selection 6863 was resistant; selection 6893 and 6880 were resistant-non tolerant; selection 6877 was tolerant; and the remaining were both susceptible and good hosts (Table 13).

At the HITA Farm at Isabela the following soil treatments increased significantly the dry weights of plants: 33.69 kg ia/ha of Fensulfothion and 186.6 lts ia/ha of Vorlex (Table 14).

In an experiment conducted at the Isabela Substation (UPR, Mayaguez Campus) soil treatments with 44.96 kg ia/ha of Carbofuran resulted in the best increase of plant dry weights ($P=0.05$). This was followed by 22.48 kg ia/ha of Carbofuran and 10 kg ia/ha of Aldicarb (Table 15). The intermediate (22.48 kg ka/ha) and higher dosage (44.96 kg ia/ha) of Ethoprop were phytotoxic, affecting seed germination and plant growth.

The most commonly encountered nematode species in the three field experiments were: P. zeae, Helicotylenchus spp., Tylenchus sp., Tylenchorhynchus sp., Aphelenchus sp., and Aphelenchoides spp.

IV - Herbicides

An experiment was established at the Lajas Substation farm on a Vertisol, Santa Isabel clay soil. Sixteen grain sorghum lines were planted on single rows 3 feet apart on February 2, 1977. Since the soil was very dry, furrow irrigation was applied the following day to induce germination and prior to herbicide application to avoid movement of chemicals from treated areas.

Herbicide treatments were applied on February 9, 1977 at right angles to the rows. A compressed-air field plot sprayer was used for herbicide application. The spray swath was 6 ft. wide. Herbicide plots were 10 ft. wide x 60 ft. in length. Treatments were: (1) Hand-weeded check, (2) Atrazine (2-cloro-4-=(ethylamino)-6-(isopropylamino)-s-triazine) at 3 lb. a.i./acre, (3) Propazine

(2-chloro-4, 6-bis (Isopropylamino)-s-triazine) at 3 lb/A, (4) Terbutryn (2-= (tert-butylamino)-4-(ethylamino)-6-(methylthio)-s-triazine) at 3 lb/A, (5) Metribuzin (4-amino-6-tertbutyl-3- (methylthio)-as triazine-5-(4H)-one) at 1 lb/A, (6) Velpar TM (3-Cyclohexenyl - 6 - dimethylamino-1-methyl-s-triazine-2,4 (1H, 3H)= dione) at 1.5 lb/A, (7) Linuron (3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea) at 2 lb/A, (8) Linuron plus Propazine at 1/2 lb/A, (9) Atrazine plus Terbutryn at 1.5/1.5 lb/A, (10) Atrazine plus Propachlor (2-chloro-N-isopropylacetanilide) commercially known as Ramrod/Atrazine at 5.5 lb a.i./acre, and (11) Non-weeded check.

Hand-weeded plots were weeded on February 23. Weeds from all plots, except Hand-weeded plots, were harvested on March 23 from the center part of each plot in an area 3 ft. x 54 ft. Data on weed weights and percent weed infestation compared against the Non-weeded check is presented in Table 16 in decreasing order of weed control. As has been observed during the past two experiments the best herbicide treatment has been Atrazine plus Terbutryn. The combination of Atrazine plus Propachlor is also good for weed control.

The experiment was fertilized at planting time with 1000/lb/acre of 15-5-10 N P K fertilizer. Plants were irrigated about every two weeks and sprayed with malathion for insect control, twice.

V - Breeding

Fifty grams of the population TP_4RO_4 segregating for the male sterile gene ms_3 was received from Dr. D.T. Rosenow from the Texas Agricultural Experiment Station. Germination was very poor and the ms_3 gene was secured by hand pollinating the few plants germinated, among them some male sterile ones. These male sterile plants were harvested and seed planted again with lines selected from the 1975 All Disease Nursery, the Sorghum Conversion Program and some lines from the Texas Winter Nurseries (Table 17). These lines were selected for their resistance or tolerance to the most important diseases or for their head appearance. Hand pollination was done among these lines and the male sterile ones. The latter were harvested and planted again in isolation for the first cycle of random mating.

Male sterile plants were tagged at bloom and harvested at maturity. Equal quantities of seed from each of the plants harvested in the first cycle of random mating were composited for the second cycle of random mating. Some of the seed was handed to Dr. Antonio Sotomayor from the Mayaguez Institute of Tropical Agriculture.

Operational Significance

The research on this project was intended to supplement other research underway at the Mayaguez Institute of Tropical Agriculture, and the Universities of Texas, Nebraska and Purdue. The research findings were to be directed toward the needs of less developed countries (LDC's) in the tropics.

Research findings showed that sorghum pests are common in all sorghum producing areas and most of the results are applicable to other areas.

Side Effects of the Work

No information and insights beyond those expected in the scope of the work were developed by the research done in the project and no unexpected complications for the applications of the findings were encounted by the same.

Dissemination and Utilization of Research Results

Dr. Alejandro Ayala, the nematologist working in the sorghum project attended and had participation in an Annual Meeting of the Organization of Tropical American Nematologist and Symposium on Nematodes of Tropical Crops in Perú. He gave a lecture on the control of nematodes on sorghum and has active participation in the discussion on Teaching Nematology in Tropical America.

Dr. Abad Morales attended and had active participation in the annual meetings of the Central American Cooperative Program for the Improvements of Food Crops (PCCMCA) in Costa Rica and Panamá.

Most of the Central and South American Countries showed interest in the project and requests for information and material were received. Sorghum seed was sent to El Salvador, Nicaragua, Ecuador and Trinidad-Tobago.

The following publications were issued:

1- Bee-Rodríguez, D. and A. Ayala. 1977. Interaction of Pratylenchus zeae with four soil fungi on sorghum. The Journ. of Agric. U.P.R. Vol. LXI (4). 501-506.

2- Ayala, A. and D. Bee. 1978. Control of phytoparasitic nematodes attacking sorghum (sorghum bicolor (L) Moench) in Puerto Rico. The journ. of Agric. U.P.R. Vol. LXII (1). 119-132.

3- Ayala A. 1977. The nematodes associated with sorghum (sorghum bicolor (L) (Moench), Nematropica.

4- Agronomic evaluation of forage sorghum. In preparation.

5- Hernández-Catalán, O.V. Nemátodos del Sorgo (Sorghum bicolor (L) Moench) en Puerto Rico. Patogenicidad y Combate, MS Thesis, Univ. of Puerto Rico, Mayaguez Campus, 1977.

Table 1. Evaluation of sorghum lines for the attack of the fall armyworm, *Spodoptera fungiperda*, Isabela Substation - September 13, 1976

Designation	Damage Index 1/
IS 12526C	1.0
IS 6440C	1.0
IS 6418C	1.0
IS 12556C	1.0
IS 12656C	1.0
IS 5769C	1.0
IS 12680C	1.0
IS 7769C	1.3
IS 7340C	1.0
IS 12573C	1.0
IS 3814C	1.0
IS 1526C	1.0
IS 5887C	1.0
IS 7776C	1.0
IS 2757C	1.0
IS 1121C	1.0
IS 7367C	1.0
IS 7541C	1.0
IS 5892C	1.0
IS 1139C	1.0
IS 1140C	1.0
IS 1151C	1.0
IS 6845C	1.1
IS 7735C	1.1
IS 12551C	1.1
IS 6982C	1.1
IS 2562C	1.1
IS 12575C	1.1
IS 7769C	1.5
IS 4884C	1.5
IS 12612C	2.5

1/ From 1 to 5, 1 represent the damage-free and 5 the most affected plants.

Table 2. Evaluation of sorghum lines for the attack of the corn earworm, *Heliothis zea*, Isabela Substation - October 18, 1976.

Designation	Infested heads a/
IS 12526C	0.0
IS 6418C	0.0
IS 5887C	0.0
IS 6845C	0.0
IS 12680C	0.0
IS 6882C	0.0
IS 12575C	0.0
IS 7769C	0.0
IS 5892C	0.0
IS 7735C	0.0
IS 7340C	0.0
IS 12612C	0.0
IS 7776C	0.0
IS 7541C	0.0
IS 4884C	0.0
IS 5769C	0.1
IS 12656C	0.1
IS 2757C	0.1
IS 3814C	0.3
IS 1121C	0.5
IS 1140C	0.5
IS 6440C	0.6
IS 1526C	0.6
IS 1139C	0.8
IS 12551C	1.1
IS 12573C	1.2
IS 7367C	1.3
IS 1151C	2.4
IS 12556C	2.8
IS 2662C	3.6

a/ Average of 4 replicates

Table 3. Evaluation of sorghum lines for the attack of the webworm *Sathrota* sp. and number of larvae/head. Isabela Substation October-November 1976.

Designation	Damaged Heads 1/	Number of larvae Per head a/
IS 12526C	0.0	15.0
IS 6418C	0.0	35.0
IS 1140C	0.0	-
IS 5887C	0.0	10.5
IS 12551C	0.0	6.0
IS 6845C	0.0	6.3
IS 12680C	0.0	-
IS 6882C	0.0	14.0
IS 2757C	0.0	7.0
IS 12575C	0.0	12.0
IS 7769C	0.0	5.0
IS 1139C	0.0	22.0
IS 5892C	0.0	6.0
IS 5769C	0.0	23.0
IS 1526C	0.0	18.7
IS 7776C	0.0	30.0
IS 7541C	0.0	-
IS 4884C	0.0	5.0
IS 3814C	0.3	20.0
IS 12656C	0.6	-
IS 7735C	0.6	3.0
IS 7340C	0.6	-
IS 12612C	0.6	24.0
IS 2662C	1.0	14.0
IS 12573C	2.0	11.6
IS 1151C	2.0	23.3
IS 7367C	2.0	-
IS 1121C	2.0	30.0
IS 12556C	2.6	-
IS 6440C	3.0	27.0

a/ Average of 4 replicates

Table 4. Evaluation of sorghum lines for the attack of the corn earworm, *Heliothis zea*. Isabela Substation - December 13, 1976.

Designation	Infested Heads[a/]
IS 7787C	0.0
IS 5394C	0.0
IS 3956C	0.0
IS 7444C	0.0
IS 7254C	0.0
IS 6271C	0.0
IS 12539C	0.0
IS 12662C	0.0
IS 12587C	0.3
IS 12685C	0.3
IS 7447C	0.3
IS 12588C	0.3
IS 12537C	0.6
IS 7778C	0.6
IS 12658C	0.6
IS 3955C	1.0
IS 2198C	1.0
IS 1143C	1.3
IS 12657C	1.3
IS 2478C	1.6
IS 1134C	2.0
IS 7440C	2.0
IS 2169C	2.0
IS 2246C	2.3
IS 2757C	2.3
IS 7379C	2.6
IS 6440C	2.6
IS 4839C	3.3
IS 12551C	3.3
IS 3464C	3.6
IS 2556C	5.0

a/ Average of 4 replicates

Table 5. Evaluation of sorghum lines for the attack of the webworm *Sathrota* sp. Isabela Substation - December 1976

Designation	Infested Heads a/	Damaged Index b/
IS 2169C	0.0	1.0
IS 7787C	0.0	1.0
IS 12537C	0.0	1.0
IS 5394C	0.0	1.0
IS 3956C	0.0	1.0
IS 12635C	0.0	1.0
IS 12539C	0.0	1.0
IS 2478C	0.0	1.0
IS 2757C	0.3	2.0
IS 12658C	0.3	1.8
IS 12662C	0.3	1.6
IS 2198C	0.6	2.0
IS 3955C	0.6	1.3
IS 7778C	0.6	1.5
IS 7379C	1.0	2.5
IS 7447C	1.0	1.5
IS 7444C	1.0	2.5
IS 12657C	1.0	1.5
IS 6271C	1.3	2.0
IS 12551C	1.3	3.0
IS 1134C	1.6	3.3
IS 12575C	1.6	3.5
IS 7440C	1.6	3.8
IS 12556C	2.0	2.6
IS 6440C	2.0	2.2
IS 12588C	2.3	2.0
IS 1143C	2.6	2.5
IS 4839C	3.0	4.3
IS 2246C	3.0	4.0
IS 7254C	3.3	2.5
IS 3464C	4.0	4.2

a/ Average of 4 replicates

b/ From 1 to 5, where 1 represent damage-free and 5 the most affected plants.

Table 6. Evaluation of sorghum lines for the attack of the corn earworm, *Heliothis zea*. Isabela Substation - January 1977.

Designation	Infested Heads a/
IS 1159C	0.0
IS 5747C	0.0
IS 1309C	0.0
IS 12615C	0.0
IS 3625C	0.0
IS 3477C	0.0
IS 6439C	0.0
IS 12556C	0.0
IS 12618	0.0
IS 6389	0.0
IS 1207C	0.0
IS 2477C	0.0
IS 3620C	0.0
IS 6906C	0.0
IS 2177C	0.0
IS 1047C	0.0
IS 3612C	0.0
IS 12551C	0.0
IS 12599C	0.0
IS 3627C	0.0
IS 5530C	0.0
IS 1133C	0.0
IS 530C	0.0
IS 6440C	0.0
IS 3574C	0.0
IS 6710C	0.0
IS 2757C	0.3
IS 3071C	0.3
IS 5554C	0.3
IS 2508C	0.3
IS 1166C	0.3
IS 1335C	0.6
IS 3911C	0.6
IS 6456C	1.0
IS 1141C	1.3
IS 2501C	1.6

a/ Average of 4 replicates

Table 7. Evaluation of sorghum lines for the attack of the corn earworm, *Heliothis zea*. Isabela Substation. February 1977.

Designation	Damaged Index[a/]
IS 8100C	1.0
IS 12563C	1.0
IS 7907C	1.0
IS 7596C	1.0
IS 7738C	1.0
IS 7044C	1.1
Centa S-1	1.3
IS 7617C	1.3
IS 7543C	1.3
IS 12570C	1.3
IS 2757C	1.3
IS 7612C	1.3
IS 12638C	1.5
IS 6895C	1.6
IS 7537C	1.6
IS 7762C	1.6
IS 6964C	1.6
IS 7524C	1.6
IS 7864C	1.6
IS 12549C	1.6
IS 7094C	1.6
Centa S-2	1.6
IS 7452C	1.6
IS 8052C	1.6
IS 7585C	1.8
IS 12635C	1.8
IS 12656C	1.8
IS 12564C	2.0
IS 7273C	2.1
IS 12551C	2.3
IS 7542C	2.3
IS 12568C	2.5
IS 7518C	2.5
IS 7173C	2.5
IS 6418C	3.1
IS 7790C	3.1
IS 7440C	3.3
IS 6440C	3.6
IS 7809C	3.8
IS 12556C	3.8

a/ From 1 to 5, where 1 represent the damage-free plants and 5 the most affected.

Table 8. Evaluation of sorghum lines for the attack of the webworm Sathrota sp. Isabela Substation - February 1977.

Designation	Infested Heads a/	Damaged Index b/
IS 12599C	0.0	1.0
IS 5530C	0.0	1.0
IS 1159C	0.0	1.0
IS 5447C	0.0	1.0
IS 12615C	0.0	1.0
IS 1166C	0.0	1.0
IS 3625C	0.0	1.0
IS 3477C	0.0	1.0
IS 6439C	0.0	1.0
IS 2757C	0.0	1.0
IS 3612C	0.0	1.0
IS 6389C	0.0	1.0
IS 12318C	0.0	1.0
IS 2508C	0.0	1.0
IS 1335C	0.0	1.0
IS 5554C	0.0	1.0
IS 3620C	0.0	1.0
IS 6906C	0.0	1.0
IS 3627C	0.0	1.0
IS 1121C	0.0	1.0
IS 2177C	0.0	1.0
IS 1047C	0.0	1.0
IS 3071C	0.0	1.0
IS 1133C	0.0	1.0
IS 3911C	0.0	1.0
IS 6440C	0.0	1.0
IS 1207C	0.3	1.1
IS 6710C	0.5	1.3
IS 1309	0.6	1.5
IS 12556C	0.6	1.6
IS 12551C	1.0	2.1
IS 3574C	1.0	1.1
IS 1141C	1.6	1.6
IS 6456C	2.0	2.0
IS 2477C	2.5	2.2
IS 530C	2.6	2.1
IS 2501C	3.6	3.1

a/ Average of 4 replicates
b/ From 1 to 5, where 1 represent the damage-free and 5 the most affected plants.

Table 9. Evaluation of sorghum lines for the attack of the webworm *Sathrota sp.* and birds. Isabela Substation - March 1977.

Designation	Damaged Webworm a/	Index Birds a/
IS 7907C	1.0	4.1
IS 7524C	1.0	4.0
IS 7612C	1.0	4.5
IS 7762C	1.0	4.0
IS 12638C	1.3	2.8
IS 7585C	1.3	4.6
IS 7809C	1.3	1.0
IS 2757C	1.3	4.1
IS 7537C	1.5	4.1
IS 7596C	1.5	4.3
IS 12563C	1.5	3.1
IS 7173C	1.6	1.3
IS 7617C	1.6	4.1
IS 7738C	1.6	3.5
IS 7864C	1.6	4.3
IS 7543C	1.6	4.1
IS 7790C	1.6	4.1
IS 12570C	1.6	4.3
CENTA S-2	1.8	3.8
IS 7044C	2.0	3.1
IS 8052C	2.1	3.8
IS 6418C	2.1	2.0
IS 7542C	2.3	3.5
IS 12554C	2.3	3.0
IS 7452C	2.5	4.0
IS 8100C	2.8	1.3
IS 7518C	2.8	2.5
IS 12568	3.0	1.8
IS 6440C	3.0	1.5
IS 6964C	3.0	3.6
IS 2556C	3.1	1.6
IS 6895C	3.3	3.8
IS 12551C	3.5	
IS 7273C	3.6	2.0
IS 12549C	3.6	2.3
IS 7440C	3.6	2.1
CENTA S-1	3.8	3.6
IS 12635C	3.8	2.0
IS 7094C	4.1	1.5
IS 12656C	4.5	1.3

a/ From 1 to 5, where 1 represent the damage-free and 5 the most affected plants.

Table 10. Evaluation of pesticides for the control of sorghum insects and birds. Isabela Substation - January 1977.

Treatments	Damage Index 1/			Yield	
	Webworm	Corn Earworm	Birds	Grams Per Plot a/	Grams Per head
Lannate 1.8L 2 pta./cda	1.0 **	1.1	1.5 **	1333.25	39.69
Arazan 42S 2 gal/cda	1.6 **	1.1	1.5 **	1355.25	44.68
Sevin 80 WP 2.5 lb/cda	1.6 **	1.3	2.1	1186.75	38.44
Thiodan 2E 2 pta./cda	1.8 *	1.5	2.6	1400.50	34.59
Diazinon AG500 1 pta/cda	2.0 *	1.6	2.0 *	1024.00	43.92
Dipel W.P.	2.1	1.3	1.7 *	1117.25	41.45
Vydate 2L 2 pta/cda	2.1	2.0	1.8 **	889.25 *	39.13
Mesurol 3 lb/cda	2.2	1.2	2.2	1317.50	42.19
Furadan 4F 2 pta/cda	2.2	1.5	2.6	1619.25	41.85
Control	3.12	1.3	2.8	1107.50	35.72

1/ From 1 to 5, where 1 represent damage-free and 5 the most affected plants
a/ Plot of 10 x 9 ft.
* Significant at the 5% level when compared with the control.
** Significant at the 1% level when compared with the control.

Table 11. Foliar disease rating for leaf blight (*Helminthosporium turcicum*) in the 1976 All Disease and Insect Nursery.

Entry No.	Designation	Rating
1	SC33-14	2.0
2	56-14	3.5
3	108-14	3.5
4	109-12	2.5
5	TAM 428 (110-9)	3.0
6	SC110-14	4.0
7	112-14 (1104c)	3.0
8	112-14 (4c)	2.5
9	120-14-1	3.0
10	170-6-8-8 (4252)	3.0
11	170-6-17 (4261)	3.5
12	170-14E-3	4.0
13	167-14	2.5
14	173-12-6	3.0
15	TAM 2566 (175-9)	2.5
16	SC 175-14	2.5
17	237-14	1.0
18	239-14	1.5
19	242-14	3.5
20	279-14	2.5
21	324-12-2	2.5
22	325-12-PL	2.0
23	326-6	1.0
24	330-9-PL	2.5
25	414-12E-PL	3.0
26	420-12	0.0
27	423-14 (2680)	3.0
28	566-14	2.5
29	574-6-PL	1.0
30	599-6-3 (9247)	4.0
31	599-6-10 (9188)	3.0
32	599-11E	4.0
33	748-5-3	4.0
34	NSA 440-12	3.0
35	NSA 935-6	1.5
36	QL3 sel.	3.0
37	B3197 x 170-6 (1750)	3.0
38	B3197 x 170-6 (1753)	3.0
39	B3197 x 170-6	3.5
40	SC110-9 x SC120-6 (4130)	3.0
41	SC599-6 x SC134	2.0
42	SC120-6 x Tx7000	2.5
43	IS2930 x IS 3922	3.0
44	SC56 x SC170 (158-1)	4.0
45	SC56 x SC33 (1778)	3.5
46	SC56 x SC33 (1790)	5.0

Entry No.	Designation	Rating
47	(B406 x Rfo)-2	3.0
48	TAM 430 (Tx2536 x 170)	1.5
49	SC 599-6 x SC 110-6	3.5
50	(B3197 x SC 170)7-3-1-3-1-3 (7505)	2.5
51	SC 984-5	2.5
52	990-8-7-1	2.5
53	TP1-24-2	3.0
54	TP1-105-1	4.0
55	TP1-382-4	3.0
56	TP1-382-4	3.0
57	TP2-76-3	3.5
58	TP4-2	3.0
59	SC599 x SC110	3.5
60	(411 x 170) 170 x (134x170) F_5	3.5
61	(411 x 170) 170 x (134x170) F_5	3.0
62	RMP1 (S) $C1_1$ (Millet)	0.0
63	SC 103-12	5.0
64	TAM 2567	2.0
65	Tx 2536	3.0
66	Tx 09	5.0
67	Tx 7078	4.0
68	BTx 398	3.0
69	BTx 378	3.0
70	Sweet Sudan	5.0

Table 12. Effect of different inoculum levels of the nematode *Pratylenchus zeae* on three growth parameters of the sorghum variety Dekalb E 57 (*Sorghum bicolor*)

Inoculum levels	Height (cm) X	Fresh weight (g)	Dry weight (g)
0	65.8 a	19.50 a	7.50 a
100	61.8 a	19.72 a	6.86 ab
200	61.8 a	18.26 ab	7.26 ab
400	65.0 a	18.04 ab	6.62 ab
800	62.0 a	17.94 ab	6.84 ab
1,600	68.8 a	17.96 ab	5.48 bc
3,200	57.6 a	13.64 b	4.30 c

X = Figures with the same letter are not significantly different according to Duncan's multiple range test.

Table 13. Reaction of 10 sorghum selections to a natural population of phytoparasitic nematodes

Selection	Yields (kg/ha) Treated 2	Yields (kg/ha) Not treated	Height (m) Treated	Height (m) Not treated	Fresh weight (kg/ha) Treated	Fresh weight (kg/ha) Not treated
6860	3,400	2,900b[X]	1.27**	1.06 bc	15,600**	12,600 a
6862	2,850**[1]	2,300b	1.10	1.02 bc	16,600**	13,250 a
6863	2,800	3,000b	1.22	1.15 b	14,850	13,100 a
6877	2,900	2,750b	0.97	0.92 c	21,100	17,500 a
6879	3,200**	2,700b	1.04	0.95 c	17,250	17,500 a
6880	3,250	2,950b	1.27	1.15 b	22,350**	18,100 a
6881	3,250**	2,350b	1.48**	1.36 a	21,500**	15,350 a
6882	2,900**	2,300b	1.07	0.98 bc	19,500**	15,350 a
6886	2,050**	1,400c	1.25	1.17 b	21,850**	13.350 a
6893	4,350**	3,850a	1.18	1.10 bc	16,350	12,350 a

X = Figures with the same letter are not significantly different according to Duncan's multiple rang test (P=0.05).

1 = ** Significant differences at the 1% level between plants treated and not treated.

2 - Fensulfothion 33.69 kg ia/ha.

Table 14. Effect of 3 dosages of 3 nematicides applied at planting time on the growth and yields of the sorghum selection Dekalb E-57

Nematicide	Dosage	Height (m)	Fresh weight (kg/ha)	Dry weight (kg/ha)
Fensulfothion	11.24 X/	1.196 a Z/	16,800 bc	3,505 d
Fensulfothion	22.48	1.250 a	19,450 ab	3,675 d
Fensulfothion	33.69	1.233 a	19,600 a	4,030 a
D-D Y/	93.4	1.197 a	16,100 cd	3,590 e
D-D	186.8	1.233 a	19,350 abc	3,780 c
D-D	373.6	1.158 a	19,400 ab	3,780 c
Vorlex Y/	93.4	1.146 a	17,550 abc	3,780 c
Vorlex	186.8	1.208 a	19,750 a	3,940 ab
Vorlex	373.6	1.205 a	19,400 ab	3,890 b
Testigo		0.900 b	13,850 d	2,700 c

X/ Equivalent to kg ia/ha.

X/ Equivalent to lts ia/ha.

Z/ Figures with the same letter are not significantly different according to Duncan's multiple range test (P = 0.05).

Table 15. Effect of 3 dosages of 3 different nematicides applied at planting time on the growth and yields of the sorghum selection Dekalb E-57.

Nematicide	Dosage	Height (m)	Fresh weight (kg/ha)	Dry weight (kg/ha)
Carbofuran	11.24 X/	1.091 bcd Y/	25,155 abc	7,250 ab
Carbofuran	22.48	1.131 ab	26,080 ab	7,330 ab
Carbofuran	44.96	1.108 abc	27,515 a	8,330 a
Aldicarb	11.24	1.150 ab	26,480 ab	7,500 ab
Aldicarb	22.48	1.171 a	25,500 abc	7,330 ab
Aldicarb	44.96	1.146 ab	24,975 abc	7,000 ab
Ethoprop	11.24	1.040 cde	21,550 bcd	6,500 bc
Ethoprop	22.48	1.005 de	21,365 cd	6,415 bc
Ethoprop	44.96	1.031 e	15,775 e	4,833 d
Testigo		1.089 de	18,435 de	5,165 cd

X/ Kg ia/ha.

X/ Figures with the same letter are not significantly different according to Duncan's multiple range test (P = 0.05).

Table 16. Weed weights (lb) and percent weed infestation

Treatment	lb/A a.i.	Weed weight lb/plot	Weed infestation %
Metribuzin	1.0	22.0	26
Atrazine + Terbutryn	1.5 + 1.5	24.0	29
Atrazine + Propachlor	5.5	28.6	34
Velpar*	1.5	45.5	55
Linuron + Propazine	1.0 + 2.0	48.4	58
Terbutryn	3.0	50.6	61
Atrazine	3.0	57.0	68
Linuron	2.0	58.5	70
Propazine	3.0	68.0	82
Non-weeded check	---	83.0	100

*Some toxicity symptons observed on plants treated. Slight toxic symptons observed with Linuron.

Table 17. Lines used in the development of PR4BR (Selections from 1975 ADN; SC and Texas Winter Nurseries)

Designation	Seed color	Plant Height (cms)	Disease Rating (Zummo scale)		
			Helminth.	Anthrac.	Rust
1. ADN250	Yellow-white	112.3	3.0	2.0	2.5
2. P721	White	103.5	Opaque line		
3. ADN263	Yellow	129.4	3.0	2.0	1.0
4. CENTA S-1	White	108.7	Commercial cultivar from El Salvador		
5. IS 12526C	White	96.7	4.5	3.5	3.0
6. ADN207	White	98.1	2.5	0.0	1.0
7. ADN257	White	102.3	3.5	2.5	2.0
8. TAN2566	Brown	73.1	3.5	3.0	1.0
9. ADN234	Yellow	101.0	2.0	2.0	2.0
10. ADN 110	Brown	81.9	3.5	3.0	3.0
11. ADN242	Yellow-white	99.0	1.0	0.0	1.0
12. ADN256	Brown	72.5	3.5	3.0	1.0
13. ADN124	Brown	99.6	4.0	3.0	3.0
14. ADN109	Brown	84.1	4.0	3.0	1.0
15. ADN134	Brown	105.5	3.5	2.5	1.0
16. ADN126	Yellow	99.0	3.0	2.5	2.5
17. ADN264	Yellow	68.0	3.0	2.0	2.5
18. ADN170	Yellow	69.6	3.5	3.0	3.0
19. ADN121	Yellow	119.3	3.0	3.0	2.0
20. ADN206	White	74.4	2.0	2.0	3.0
21. ADN248	White	112.1	3.0	3.5	2.0
22. ADN155	Yellow	129.5	3.0	2.0	1.0

Cont. Table 17.

Designation	Seed color	Plant Height (cms)	Disease Rating (Zummo scale)		
			Helminth.	Anthrac.	Rust
23. ADN156	Brown	100.9	3.5	3.0	1.0
24. ADN231	Brown	111.4	3.0	3.0	4.0
25. ADN241	Yellow	108.5	3.0	2.0	2.5
26. ADN265	Yellow	104.8	4.0	2.0	2.0
27. ADN227	Brown	131.5	3.0	3.0	2.0
28. ADN145	Brown	100.5	4.0	3.0	2.0
29. ADN151	Yellow	104.0	3.5	3.0	3.5
30. ADN208	White	116.6	2.5	2.0	2.5
31. ADN257	Yellow		3.5	2.5	2.0
32. ADN205	White	66.6	3.0	2.0	2.5
33. ADN201	Yellow	90.8	3.0	2.0	2.5
34. ADN 161	Brown	104.5	3.5	2.0	1.0
35. ADN224	Yellow	131.0	3.0	3.0	2.5
36. ADN169	Brown	109.2	3.0	3.0	4.0
37. ADN118	Yellow	118.6	3.0	3.0	2.0
38. ADN247	Yellow		3.0	3.5	3.0
39. ADN240	Brown	90.1	3.0	2.0	2.5
40. ADN152	Brown	80.3	3.0	2.0	2.5
41. ADN111	Brown	71.3	3.5	3.0	1.0
42. ADN120	Brown	100.3	3.5	3.5	2.0
43. ADN128	Brown	86.3	4.0	3.0	3.0
44. ADN147	Brown	94.9	3.0	2.5	5.0
45. ADN149	Yellow	107.0	3.0	1.0	4.0
46. ADN150	White	98.6	2.5	2.0	2.5
47. ADN158	White	91.0	0.0	1.0	2.0
48. ADN165	White	126.7	3.0	3.5	2.0

Cont. Table 17.

Designation	Seed Color	Plant Height (cms)	Disease Rating (Zummo scale)		
			Helminth	Anthrac.	Rust
49. ADN166	Brown	94.5	2.5	3.5	1.0
50. ADN 212	Brown	109.7	3.0	2.5	3.5
51. ADN213	Yellow	94.6	3.0	1.0	4.0
52. ADN220	Brown	85.0	2.5	3.5	1.0
53. ADN223	Yellow	116.3	3.0	3.0	2.0
54. ADN230	Brown	93.9	3.0	2.5	5.0
55. ADN233	Brown	139.2	3.5	2.0	1.0
56. ADN244	Brown	111.5	3.5	2.5	4.5
57. ADN245	Brown	96.2	3.5	3.5	1.0
58. ADN253	Yellow	89.6	3.0	3.0	3.0
59. ADN260	Brown	90.3	4.0	3.0	3.0
60. ADN 266	Yellow	109.8	3.0	3.0	2.0
61. ADN270	Brown	90.0	4.0	3.0	3.0
62. SC356	White	91.3	4.5	4.0	3.0
63. SC242	White	124.1	3.5	2.0	2.0
64. SC426	Brown	100.1	5.0	3.5	4.0
65. SC6	Brown	111.5	4.5	3.5	3.0
66. SC36	Brown	125.2	3.5	2.0	3.0
67. SC405	Brown	89.2	4.0	3.0	3.0
68. SC165	White	87.6	2.5	2.5	2.5
69. SC147	White	104.6	3.0	2.0	2.0
70. SC239	White	69.0	2.5	2.5	2.5

Cont. Table 17.

Designation	Seed Color	Plant Height (cms)	Disease Rating (Zummo scale)		
			Helminth	Anthrac.	Rust
71. SC256	White	177.0	3.0	3.0	2.0
72. SC320	White	103.7	3.0	3.0	4.0
73. SC97	Yellow	154.4	3.0	3.0	2.5
74. SC290	Yellow	101.8	3.5	2.5	1.0
75. SC549	Brown	95.9	3.0	2.5	3.0
76. SC372	Yellow	104.2	3.0	3.0	3.0
77. SC298	Yellow	154.5	2.5	3.0	3.0
78. SC203	Yellow	75.5	3.0	2.5	2.0
79. SC402	Yellow	88.0	3.0	3.0	2.5
80. SC229	Yellow	52.9	3.0	3.0	2.5
81. Tx430	Lines selected from the 1975 Texas Winter Nursery for their good heads.				
82. 310					
83. 320					