AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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Batch #22

1. SUBJECT CLASSIFICATION

A. PRIMARY: Serials — Y-AF30-0170-0000

B. SECONDARY: Agriculture--Plant breeding--Cereals--Sorghum

2. TITLE AND SUBTITLE

Development of improved high yielding sorghum cultivars; semi-annual report, Feb.-Aug.1974

3. AUTHOR(S)

(101) Tex.A&M Univ.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1974	30p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS

Tex.A&M

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

(Research summary)

9. ABSTRACT

10. CONTROL NUMBER	11. PRICE OF DOCUMENT
PN-RAB-297	
12. DESCRIPTORS	**13. PROJECT NUMBER**
Sorghum	
	14. CONTRACT NUMBER
	AID/ta-C-1092 Res.
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

(no publications listed)

First

Semiannual Report

on

DEVELOPMENT OF IMPROVED HIGH YIELDING SORGHUM CULTIVARS

Contract No. AID/ta-c/1092

February 15 - August 31, 1974

Prepared by

Texas Agricultural Experiment Station
Department of Plant Sciences
and
TAES Research and Extension Center
at Lubbock

Texas A & M University
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Submitted to

Agency for International Development
Department of State
Washington, D. C.

REPORT SUMMARY

A. 1. Project Title and Contract Number: Development of Improved, High Yielding Sorghum Cultivars; Contract Number AID/ta-c-1092

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3. Contract Period: February 15, 1974 - February 15, 1976.

4. Period covered by Report: February 15, 1974 - August 31, 1974.

5. Total AID funding of contract to date: $149,946.00

6. Total expenditures and obligations through previous contract year: None

7. Total expenditures and obligations for current year: $20,016.44[1)] Estimated $74,591

8. Estimated expenditures for next contract year: Estimated $75,355

[1)] Does not include encumbrances.

B. Narrative Summary of Accomplishments and Utilization

This represents the first semiannual report and it presents a description of the extent of disease and insect resistance studies under way in sorghum. Data from only a few of the International and Domestic Nurseries are available and therefore were not summarized in this report. In general, we were extremely pleased with levels of downy mildew, head smut and zonate leaf spot from South Texas in 1974. The current growing season ends about November 15. A computer program to assist in summarization of disease, insect and agronomic observations from these nurseries programs is under study.

INDEX

Personnel ..... page 1

Introduction ..... page 2

Preliminary Disease Screening ..... page 5

All Disease Nurseries ..... page 6

International Disease Nursery ..... page 10

Uniform Head Smut Nursery ..... page 13

Lodging Resistance ..... page 16

Disease Resistant Populations ..... page 20

Disease Research Work Plan ..... page 21

Entomology Program ..... page 22

Entomology - Breeding Program ..... page 25

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INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the principal food and feed commodities of the world. Sorghum is considered by many authorities as the third most important food grain, exceeded in utilization for food only by wheat and rice. Furthermore, sorghum is well adapted to cultivation under wide extremes in environmental conditions including arid, semi-arid, and sub-tropical areas of the world where other food commodities are often less well adapted.

In southwestern USA, where sorghums are a principal agricultural commodity, serious disease and insect problems have occurred repeatedly. During the past few years, there have been grave losses caused by head smut (*Sphacelotheca reiliana*); downy mildew (*Sclerospora sorghi*); maize dwarf mosaic (MDMV); anthracnose (*Colletotrichum graminicola*); charcoal rot (*Macrophomina phaseoli*); Fusarium stalk rot (*Fusarium moniliforme*); and a number of common foliage diseases.

Insects causing significant yield losses in grain sorghum annually are the sorghum midge (*Contarinia sorghicola*) and greenbug (*Schizaphis graminum*). Banks grass mite (*Olingonychus pratensis*), is a severe problem in the great plains region. Economically injurious insects that appear to be increasing in serverity and distribution are white grubs (*Phyllophaga crinita*), sugarcane rootstalk weevil (*Anacentrinus deplanatus*), corn leaf aphid (*Rhopalosiphum maidis*), and yellow sugarcane aphid (*Sipha flava*). Consequently the need for superior sources of disease and insect resistance in sorghums is urgently needed in Texas as well as throughout the world.

In 1963, the Texas Agricultural Experiment Station and the United States Department of Agriculture initiated a program whereby exotic sorghums from the World Sorghum Collection were converted from tall, late maturing, photoperiod-sensitive types to shorter, earlier maturing, less photoperiod-sensitive lines. Conversion is accomplished by crossing and back-crossing program using the short winter days of Puerto Rico for crossing and growing F_1's with selection for short, early plants within segregating populations during the long summer days in Texas. Many exotic lines have been reported to be resistant to a number of diseases and insects, but until converted or partially converted, most of these lines are not available for use in temperate areas of the world. During the conversion process we have been able to evaluate resistance from some partially converted exotic sorghums to diseases prevalent in the United States and to some insects. Some of these sorghums possess extraordinarily high levels of disease and insect resistance.

The specific objectives of this research are:

1. To identify and define potential sources of multiple disease resistance and insect resistance in partially converted and converted exotic sorghums.
2. To develop agronomically elite populations of sorghum with high levels of multiple disease resistance and insect resistance.
3. To experimentally evaluate effectiveness and types of disease resistance from lines obtained through primary screening and from artificially synthesized populations.

4. To develop uniform methods of determining insect and disease resistance and to study, where appropriate, mechanisms of resistance.

A. Preliminary Disease Screening

Two hundred previously nonscreened exotic sorghum introductions were planted in the disease nursery at Beeville, Texas to evaluate for resistance to downy mildew, head smut, and foliage diseases. Eighty-eight of the exotics wre Nigerian lines recommended for screening by Dr. O. J. Webster, while 112 exotics are of Ethiopian origin from the Damon Collection. Also planted for disease screening in the Beeville area nurseries were 795 plots of partially converted lines. These were F_3, F_4, or advanced generation partially converted (mostly BC1 and BC2) lines, most of which had not been previously screened.

In the disease nurseries in the Beeville area, 3,200 plots of F_3 thru F_6 breeding lines, derived from crosses of disease-resistant converted and partially converted with U.S. elite lines, were planted for disease screening. At Lubbock, 3,600 plots of the same material were planted for screening for MDM and lodging resistance.

B. All Disease Nurseries (ADN)

Promising selections from the preliminary nurseries are grouped and evaluated in the "All Disease Nursery" (Table 1) for maximum range of environments and pathogens. Plants in these nurseries are being evaluated primarly on the basis of natural infection however, artificial inoculations with maize dwarf mosaic virus Helminthosporium turicium, Colletotrichum graminicola, and Macrophomina phaseoli were made at Lubbock, College Station, Meridian, Mississippi and Lubbock, respectively. The ADN is being grown in 10 field locations in 1974 and will be evaluated for downy mildew in greenhouse trials at College Station.

Table 1 1974 All Disease Nursery

Entry No.	Designation	IS No.	Variety, kind, or group
1	SC 56-14	12568	Cau-Nig
2	SC 89-9	12598	Cau-Nig
3	SC103-12	2403	Caud
4	SC108-14	12608	Zerazera
5	SC109-12	12609	Zerazera
6	SC110-9	12610	Zerazera
7	SC110-14	12610	Zerazera
8	SC111-9	12611	Zerazera
9	SC112-14	12612	Zerazera
10	SC112-14-6	12612	Zerazera
11	SC115-11E	2683	Cau-Nig
12	SC120-6	2816	Zerazera
13	SC120-14-1	2816	Zerazera
14	SC170-6-8-3	12661	Zerazera
15	SC170-6-8-8	12661	Zerazera
16	SC170-6-17	12661	Zerazera
17	SC170-12	12661	Zerazera
18	SC170-14E	12661	Zerazera
19	SC173-12	12664	Zerazera
20	SC175-9	12666	Zerazera
21	SC175-14	12666	Zerazera
22	SC228-14	2549	Zerazera
23	SC237-9	3071	Dobbs
24	SC239-14	3574	Zerazera
25	SC324-12	2681	Nigr
26	SC325-12	2462	Nigr
27	SC326-6	3758	Nigr
28	SC330-9	8187	Nig-Fet
29	SC333-14	3063	Caud
30	SC334-9	3499	Caud
31	SC414-12E	2508	Cau-Kaf
32	SC414-14	2508	Cau-Kaf
33	SC420-12	7064	Cau-Kaf
34	SC423-14-1	2579	Zerazera
35	SC423-14-2	2579	Zerazera
36	SC574-6	8337	Cau-Nig
37	SC599-6-3-1	-	Rio
38	SC599-6-3 (9245)	-	Rio
39	SC599-6-3 (9247)	-	Rio
40	SC599-6-10 (9188)	-	Rio
41	SC599-6-10 (9193)	-	Rio
42	SC599-9-3	-	Rio
43	SC599-11E	-	Rio
44	SC644-9	8237	Caf-Darso
45	SC680-3	8264	Dobbs
46	SC748-5	3552	Cau-Guin
47	SC167-14	12658	Dur-Bic
48	NSA 440	-	Kaf der
49	NSA 637	-	YE der
50	NSA 817	-	YE der

Table 1 (Continued)

Entry No.	Designation	IS No.	Variety, kind, or group
51	NSA 837	-	YE der
52	NSA 935	-	YE der
53	(B3197 x SC 170-6) (3211)	-	-
54	" (5058	-	-
55	(SC 110-9 x SC 120-6) (4117)	-	-
56	" (4130)	-	-
57	(SC 599-6 x SC 134-6)	-	-
58	(B 3197 x SC 170) (CH5)	-	-
59	(SC 120-6 x Tx 7000)	-	-
60	(IS 2930 x IS 3922)	-	-
61	(IS 8678 x IS 2046)	-	-
62	(SC 56-6 x SC 170-6) (1409)	-	-
63	72CS 2656-5	-	YE der
64	72CS 2637-2	-	YE der
65	Tx 2536	10542	YE
66	Tx 09		C. Wh. Fet.
67	Tx 7078	415	
68	B Tx 398	412	Martin
69	B Tx 378	413	Redlan
70	Sweet Sudan	721	

1974 ALL DISEASE NURSERY LOCATIONS

Location	Principal Diseases
Berclair, Texas (head smut nursery)	Head smut
Berclair, Texas (downy mildew nursery)	Downy mildew, foliage diseases
College Station, Texas	Misc. diseases
Meridian, Mississippi	Foliage diseases
State College, Mississippi	Fusarium head blight, misc.
Experiment, Georgia	Anthracnose
Manhattan, Kansas	Misc. diseases
Lubbock, Texas (regular)	Rust, misc.
Lubbock, Texas (early)	Charcoal rot, lodging
Lubbock, Texas (late)	Charcoal rot, lodging
Lubbock, Texas (very late)	MDM

C. International Disease Nursery (IDN)

Currently, the IDN is a 30-entry test composed primarily of the best multi-disease and insect resistant sorghums along with appropriate elite sorghum control varieties and disease differentials (Table 2). In 1974, the International Disease Nursery was grown or is being grown in 18 locations in 7 countries.

Table 2 1974 International Disease Nursery

Entry No.	Designation	IS No.	Variety, kind, or group
1	SC 56-14	12568	Cau-Nig
2	SC103-12	2403	Caudatum
3	SC108-14	12608	Zerazera
4	SC109-12	12609	Zerazera
5	SC110-9	12610	Zerazera
6	SC110-14	12610	Zerazera
7	SC112-14	12612	Zerazera
8	SC120-6	2816	Zerazera
9	SC120-14	2816	Zerazera
10	SC170-6-8	12661	Zerazera
11	SC170-6-17	12661	Zerazera
12	SC173-12	12664	Zerazera
13	SC175-14	12666	Zerazera
14	SC237-9	3071	Dobbs
15	SC239-14	3574	Zerazera
16	SC326-6	3758	Nigricans
17	SC334-9	3499	Caudatum
18	SC414-14	2508	Cau-Kaf
19	SC420-12	7064	Cau-Kaf
20	SC423-14	2579	Zerazera
21	SC599-6-3	-	Rio
22	SC599-6-10	-	Rio
23	SC680-3	8264	Dobbs
24	NSA440	-	Kafir deriv.
25	Tx 09	-	Comb. Wh. Fet.
26	B Tx 378	413	Redlan
27	B Tx 398	412	Martin
28	Tx 7078	415	Combine 7078
29	Tx 2536	10542	YE Fet. deriv.
30	Sweet Sudan	721	Sw. Sudangrass

1974 INTERNATIONAL DISEASE NURSERY LOCATIONS

Location (number)	Cooperator
Argentina (1)	Jose Luis Scantamburlo Manfredi
Brazil (10)	Robert E. Schaffert Sete Lagoas
India (4)	N.V. Sundaram New Delhi
Mexico (2)	Elmer C. Johnson Mexico 6, D.F.

Other Locations	Principal Diseases
Houma, Louisiana	Rust
Corpus Christi, Texas	Smut

D. The Uniform Head Smut Nursery (UHSN)

Because of the high degree of physiological race specificity of the head smut pathogen, standard differentials and key sources of resistance and grown annually in head smut problem areas. This group of 18 entries (Table 3) provides as with data on frequency of races, new races and usefulness of the sources of resistance to an ever shifting pathogen. In 1974, the UHSN was grown in 7 locations in Texas and California.

Table 3 1974 Uniform Head Smut Nursery

Entry No.	Designation	IS No.
1	SA281 (Early Hegari)	
2	PI48770 (White Kafir)	
3	Calif. # 38 (Res. D.D.Y. Milo)	
4	BTx 3197 (Combine Kafir 60)	
5	B TAM618 (Sm. Res. Kafir)	
6	Lahoma Sudan	
7	Tx 7078	
8	Tx 414	
9	RS 610	
10	RS 626	
11	SC173	12664C
12	SC103	2403C
13	SC170-6-17	
14	SC175	12666C
15	NSA817-3-4	
16	TAM428 (Sc110-9)	
17	Tx 2536	
18	B Tx 399 (Wheatland)	

1974 UNIFORM HEAD SMUT NURSERY

Location

Victoria, Texas

Berclair, Texas (head smut nursery)

Beeville, Texas

Corpus Christi, Texas

California (Pioneer)

Lubbock, Texas (P-A-G)

Plainview, Texas (ACCO) (2 sets)

E. Lodging Resistance

A 25-entry replicated Statewide Lodging Test (SLT) Table 4. containing the lines with the best lodging resistance was planted at nine locations over Texas to evaluate the lines for resistance to various type of lodging, such as root lodging, weak neck, charcoal rot-moisture stress type lodging, and after-freeze stalk breakage. In some of the locations where moisture stress occurred, charcoal rot infested toothpicks were inserted at the base of the stalks to encourage charcoal rot development.

An Advanced Lodging Test (ALT), Preliminary Lodging Test (PLT), and Hybrid Lodging Test (HLT), were also planted in Texas for lodging resistance evaluation, but at fewer sites than the Statewide Lodging Test. The ALT and PLT both contain 36 entries. The ALT contains lines which have been previously screened, and are possible candidates for the SLT. The PLT contains material with only limited screening, or new items from breeding nurseries which have not been previously screened in replicated trials. The Hybrid Lodging Test (HLT) contains 77 hybrids made with male parents that have been identified as possessing lodging resistance. The hybrids are evaluated to determine how well the resistance from each male is transferred to hybrids, and to identify those lines which transfer the highest level of resistance to their hybrids.

In addition to the replicated lodging tests, over 3,600 plots of F_3 to F_6 breeding lines will be left in the field until mid-winter and evaluated for weak neck and stalk breakage. This primary lodging screening technique of breeding material is used to select lodging resistant lines for entry into the replicated lodging tests.

Table 4 1974 Statewide Lodging Test

Entry No.	Designation	IS No.
1.	SC 33-6	IS12553
2.	SC 35-6	IS12555
3.	SC 56-14	IS12568
4.	SC170-6-8	IS12661
5.	SC170-6-17	IS12661
6.	SC237-9	IS3071
7.	SC326-6	IS3758
8.	SC599-6-10 (Rio deriv.)	-
9.	SC599-6-3 (Rio deriv.)	-
10.	NSA440	-
11.	NSA443	-
12.	NSA637	-
13.	NSA681	-
14.	NSA817	-
15.	NSA837	-
16.	(B406 x Rio)-2	-
17.	(P407 x)-47-3-4	-
18.	(SC 56-6 x SC 33)	-
19.	SC423-9	IS2579
20.	Tx 7078	IS415
21.	Tx 7000 (Crock)	IS414
22.	B Tx 399 (Wheatland)	IS896
23.	B Tx 378 (Redlan)	IS413
24.	New Mexico-31	-
25.	SA392 (Comb. Hegari)	IS119

1974 STATEWIDE LODGING TEST

Location

Berclair, Texas (head smut nursery)

Beeville, Texas

Corpus Christi, Texas

Dallas, Texas

San Angelo, Texas

Chillicothe, Texas

Lubbock, Texas (dryland)

Lubbock, Texas (charcoal nursery - early)

Lubbock, Texas (charcoal nursery - late)

Advanced Lodging Test Locations - 1974

1. Berclair, Texas (head smut nursery)
2. Beeville, Texas
3. Chillicothe, Texas
4. Lubbock, Texas (dryland)
5. Lubbock, Texas (charcoal nursery - early)
6. Lubbock, Texas (charcoal nursery - late)

Preliminary Lodging Test Locations - 1974

1. Lubbock, Texas (dryland)
2. Lubbock, Texas (charcoal nursery - early)
3. Lubbock, Texas (charcoal nursery - late)

Hybrid Lodging Test Locations - 1974

1. Beeville, Texas
2. Lubbock, Texas (dryland)
3. Lubbock, Texas (charcoal nursery - early)
4. Lubbock, Texas (charcoal nursery - late)

Disease Resistant Populations

Several populations containing elite sources of disease resistance, lodging resistance, and elite U.S. germplasm have been developed, and have been planted at Lubbock for random mating in 1974. These populations all use ms_3 as a source of genetic male sterility. The populations and their primary objectives are listed below:

Population designation	Title and objective
TP2R	Multiple disease resistant
TP3R	Downy mildew resistant
TP5RB	Broad base
TP6B	Standard B-line
TP7B	Disease resistant B-line
TP9R	Lodging resistant
TP10R	MDM resistant

Work Plan for Next Six-month Period

1. Take head smut, downy mildew, and foliage disease notes on the exotic lines and the partially converted lines.
2. Take head smut and downy mildew notes on the F_3 to F_6 breeding lines growing in the Beeville, Texas area, and take MDM and lodging notes on the F_3 to F_6 breeding lines growing at Lubbock, Texas.
3. Inoculate lodging tests with charcoal rot where moisture stress occurs, and take lodging notes on the SLT, ALT, PLT, and HLT at locations where lodging occurs.
4. Tag male-sterile plants in TP2, TP3, TP5, TP6, TP7, TP9, and TP10. These will be harvested and equal quantities of seed composited for the next generation of random mating.
5. Some of the populations will be sent to Puerto Rico for random mating in the winter '74-'75.
6. Disease resistant, lodging resistant, and insect resistant lines will be planted in a winter nursery in Puerto Rico for seed increase, crossing, and evaluation.

Entomology Program

Field screening of previously identified sorghum midge, Contarinia sorghicola (Coquillett), resistant sorghums continue to confirm significant levels of resistance. Several sorghum lines, namely, TAM 2566, SC 423 - 14, SGIRL - MR - 1, and midge susceptible sorghums have been planted to expand research into the area of determination of resistance mechanisms. Randomized complete block design test plantings have been made at bi-weekly intervals. The three classic resistance mechanisms; non-preference, antibiosis, and tolerance are presently being studied under field conditions using both artificial and natural sorghum midge infestations. Differences in sorghum maturity types and fluctuations in midge population densities are being compensated for by planting date manipulation and careful assessment of population levels. Specially designed insect cages have been constructed and are being used to allow intricate studies of resistance mechanisms. By use of these cages, accurate data on oviposition and subsequent biological development of the pest is being determined. Oviposition rate by both natural and artificial infestation of midge adults is being used as a measure of non-preference. Developmental rate of life stages and degree of adult emergence and survival is being used as measures of antibiosis. Extent of damage to infested seed and recovery of damaged seed are being used as measures of tolerance.

Work Outline For the Next Six-Month Period

A. Screening and evaluation of sorghum midge resistant sorghums.

1. Typical screening trial of regional test prepared by Dr. Jerry Johnson.

2. Evaluation of midge resistance in weekly plantings of TAM 2566, SC 423 - 14, SGIRL - MR - 1, and susceptible sorghums.

B. Determination of mechanisms of resistance of midge resistant sorghums.

1. Compare resistant and susceptible sorghums under natural infestations and determine:

   a. Egg deposition

      1. Numbers

      2. Hatching

   b. Larval development

      1. Numbers

      2. Duration

      3. Survival

   c. Adult development

      1. Emergence numbers

      2. Longevity

2. Caged heads or portions of heads with a known population level of adults.

   a. Egg deposition

      1. Numbers

      2. Hatching

b. Larval development

1. Numbers

2. Duration

3. Survival

c. Adult development

1. Emergence numbers

2. Longevity

3. Establish a greenhouse technique for maintaining a sorghum midge culture for use in laboratory research on mechanisms.

Entomology - Breeding

A greenbug (Schizaphis graminum (Rondani)), multiple disease resistant population (TP1) using ms_3 as the source of genetic sterility has been developed and is being random mated. Disease resistance contained in the population include resistance to maize dwarf mosaic virus, head smut (Sphacelotheca reiliana) and downy mildew (Sclerospora sorghi Weston and Uppal).

Forty-nine partially converted or converted exotic lines with moderate to high levels of resistance to the sorghum midge (Contarinia sorghicola (Coquillett)) have been used along with selected elite converted exotic and U.S. material to develop a random mating population (TP8). This population also contains ms_3 as a source of male sterility and is being random mated this year.

Evaluation of midge resistant material selected from the TAES breeding program and the end products of the sorghum conversion program are being conducted in several locations. These tests contain 28 entries, 10 check varieties and 18 resistant entries that have exhibited high levels of resistance in previous tests. In order to assure some test sites with high midge populations and to test the material to midge population in different geographical areas, the tests are being grown at three locations in Texas and one each in Mississippi, Georgia, Oklahoma and Mexico.

In addition, duplicate breeding nurseries containing 790 F_3 rows, 62 F_2 populations and a random mating population (TP8) are being grown at Beeville and Lubbock, Texas. Material contained in these nurseries were developed from crosses of midge resistant material and elite U.S. and converted exotic lines. These plantings will be used to study the inheritance of midge resistance and to select agronomically improved midge resistant types.

Work Outline For the Next Six-month Period

1. Identify and tag male sterile plants in random mating populations, TP1 and TP8.
2. Harvest and composite an equal quantity of seed from the male sterile heads, TP1 and TP8.
3. Make plantings to begin random mating populations of material resistant to other insects.