RESISTANCE OF NATIVE SORGHUMS FROM INDIA TO THE CORN EARWORM AND FALL ARMYWORM

By

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RESISTANCE OF NATIVE SORGHUMS FROM

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PREFACE

At the Entomological Society of America, Southwestern Branch meeting in 1967, Dr. A. W. A. Brown talked about the development of insecticide resistance by insects. Since hearing this talk, I have been interested in the control of insects without insecticides. The same year, Dr. Harvey L. Chada, Professor of Entomology, Oklahoma State University, and Investigations Leader, Entomology Research Division, U. S. Department of Agriculture, impressed upon me the need for finding crop varieties which are resistant to insect attack.

I would like to express my sincere appreciation to my major adviser, Dr. Harvey L. Chada, for his helpful suggestions and assistance in conducting the tests and in the preparation of this manuscript.

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INTRODUCTION

The development of insecticide resistance by pest species, toxic residue problems, and costs of insecticides when used on low-value-per-acre crops has brought about the realization that all means of insect control must be employed. Because of this situation with respect to sorghums, the use of resistant varieties may offer an ideal means of insect control.

The use of resistant varieties differs from other insect control measures in being a cumulative and persistant type of control. The use of insecticides causes a sudden and usually drastic reduction in the insect population, but then decreases in effectiveness until reapplied. Insect control by parasites and predators is often cyclic and dependent upon the presence of large host populations before they become effective, also, the alternation of numbers of parasites and predators and host insects allow the pest to damage the crop before it is controlled.

Grain sorghums, *Sorghum bicolor* (Linn.) Moench, are frequently infested with a number of insects, and resulting damage can be severe. The corn earworm, *Heliothis zea* (Boddie), and fall armyworm, *Spodoptera frugiperda* (J. E. Smith), also consistently cause damage to grain sorghums.

Corn earworms in grain sorghum can destroy 30 to 50 percent of the grain in infested heads, small numbers per head constituting an economic loss to the farmer.

In Oklahoma, grain sorghum yield loss to insects, according to survey reports, was estimated to be 1, 034, 236 bushels in 1967, 779, 889 in 1966, and 1, 213, 656 in 1965. The estimated loss in dollars per acre was $10. 94 in 1967, $8. 06 in 1966, and $8. 40 in 1965. The corn earworm was listed as the number one pest all three years. The fall armyworm was listed as the number two pest in 1966, doing 15 percent of the total damage.

The search for sorghum varieties with resistant germ plasm for use by plant breeders is very important. The objectives of this study were to find sorghum varieties possessing resistant germ plasm to the corn earworm and the fall armyworm. This study was initiated by making a preliminary testing of 355 varieties of sorghums from India for resistance. If resistant varieties are found, they are to be used by plant breeders in the development of sorghum hybrids with resistance to the corn earworm and fall armyworm.

REVIEW OF LITERATURE

Painter (1966) commented on the treatment given in textbooks of applied entomology to the use of resistant varieties, especially long-standing ones. Information in most cases ranged from somewhat less than enthusiastic comment to statements that indicated gross misinformation. Young (1969) stated that the use of resistant varieties might be the panacea of insect control if a high level of resistance were available for most crops. The use of resistant varieties is an ideal method of protecting crops from insect damage (Beck 1965). Packard and Martin (1952) further stated that after a resistant variety has been developed and tested, there is little expense or effort required of the individual grower. Most resistant varieties vary from near immunity to only a low level of resistance. There have been some spectacular successes in which resistance alone is a highly effective means of insect control Among these are phyloxera resistant grapes, Hessian fly resistant wheat, and greenbug resistant barley (Snelling 1941[a] and Beck 1965). Painter (1941) stated that an important part of any insect control project should be the search for, and use of, resistant varieties.

The recent appearance of new greenbug biotypes (Wood 1961a), to which certain experimental "resistant" host strains are not resistant, emphasizes that host resistance is not a panacea or ideal, even though it may be the best method.

Painter (1951) stated that, "Resistance is the relative amount of heritable qualities possessed by a plant which influences the ultimate degree of damage done by the insect. In practical agriculture it represents the ability of a certain variety to produce a larger crop of good quality than do ordinary varieties at the same level of insect population." Various definitions of resistance have been given by Snelling (1941), Painter (1954, 1966), and Beck (1965). The definition of resistance to be used in this manuscript is that given above by Painter.

Painter (1941) further divided resistance into the categories of preference, tolerance, and antibiosis. Preference is described as plant qualities which influence the insect to prefer one plant over another and may be shown in respect to oviposition, food, or shelter. Tolerance is defined as the ability of a plant to withstand insect attack. A tolerant plant may repair, recover from damage, or it may simply withstand the attack. Plant qualities which cause an adverse effect on the biology of an insect is defined as antibiosis. A plant with antibiotic qualities may cause a continuing and cumulative decrease in the insect population because of the adverse effect the plant has on the fecundity of the insect (Painter 1954).

The use of resistant varieties for control of insects is not a new concept. The oldest published record of plant resistance is by

J. N. Havens in 1792, in which he recognized the Underhill wheat variety as showing resistance to the Hession fly. Other early advocates of plant resistance were Chapman 1788, Lindley 1831, and Fitch 1869. By 1931, there were over 100 different crops with insect resistant varieties (Snelling 1941a).

The chance of finding resistance is more or less proportional to the number and diversity of the plants and varieties of a crop species that can be studied (Painter 1966). Several workers have screened a large number of small grains to find germ plasm with resistance to insects: Dahms et al. (1955), Painter and Peters (1956), Chada et al. (1961), Wood (1961b), and Hormchong and Wood (1963) are a few of the many workers on small grains. Many small grain varieties have been developed which are resistant to pest species.

Although a considerable amount of work has been done on developing insect resistant sorghum varieties, most of it was for chinch bug resistance. Resistance of sorghum plants to insect attack has been described by Snelling et al. (1937), Snelling and Dahms (1937), Dahms and Martin (1940), Dahms (1943), Painter (1951), Dicke et al. (1963), and Hormchong (1967).

Resistance of sorghums to the chinch bug has been described by Parker (1931), Martin (1933), Snelling et al. (1937), Snelling and Dahms (1937), McDowell (1944), Sieglinger (1946), Blizzard (1948), and Dahms and Martin (1940). Many sorghum varieties have been found with resistance to the chinch bug. Atlas sorgo, Sunrise sorgo, Western Blackhull, Cheyenne, Club, and Dawn Kafir are a few of the sorghum varieties found to be chinch bug resistant.

There are several references to research conducted on sorghum resistance to grasshoppers, corn leaf aphids, and sorghum midge.

Hayes (1922) and Brunson and Painter (1938) conducted studies on grasshopper resistant sorghum varieties. Kafirs, feteritas, and sorgos were found to be more resistant to grasshopper attack than milos or hybrids involving milos.

McCollock (1921) reported on resistance of 17 varieties of sorghum to the corn leaf aphid. Sudan varieties were found to be highly resistant to corn leaf aphid attack.

Sorghum varieties possessing resistance to the sorghum midge were reported by Ball and Hastings (1912) and Karper et al. (1932). Ball and Hastings (1912) reported that sumac sorgo appeared to be resistant. Karper et al. (1932) reported that Darso and Schrock might be resistant. Walter (1941) studied 47 varieties of sorghum but reported no varieties showing signs of being resistant.

There is very little information on sorghum resistance to Lepidopterous pests. Dahms (1943) stated, "The use of resistant varieties to lessen injury from insects that attack sorghums would appear to deserve more attention, because the control of insects on a crop of low value per acre precludes the use of insecticides." Sorghum damage by Lepidopterous pests attacking sorghums often are not serious enough to warrant the use of insecticides, but their control by resistant varieties could bring a sizeable economic return to the farmer.

Hsu (1936) reported on sorghum infestations of stem borers in north China and showed that the degree of infestation is probably a heritable character. He also found that sorgos were more susceptible than varieties which possessed white grain. Quinby and Gains (1942) reported on corn earworm resistance of sorghum heads with a loose panicle as opposed to those varieties with compact panicles. Wilber, Bryson, and Painter (1950) reported on southwestern corn borer development in sorghums in Kansas. Dicke et al. (1963) evaluated the resistance of sorghum varieties and hybrids to the European corn borer during a period of three years. Hormchong (1967) screened 144 sorghum varieties for resistance to the corn earworm and fall armyworm and 75 for resistance to the southwestern corn borer. He found 40 varieties indicating resistance to the corn earworm, 34 indicating resistance to the fall armyworm, and 20 indicating resistance to the southwestern corn borer.

A reliable criterion by which to measure resistance is essential in conducting a search for resistant varieties (Beck 1965, Painter 1966). Neiswander (1948) described a 1-5 rating system to quickly evaluate differences in susceptibility or resistance of corn varieties to the European corn borer. A 0-9 rating system was used by Guthrie et al. (1960) to evaluate leaf feeding by the European corn borer. Wiseman et al. (1966) detected differences in reaction of corn seedlings in the greenhouse to fall armyworm infestation by visual classification of damage, using a rating system 0-10. Chada et al. (1961) described a 0-5 rating system which is a measure of the estimated percentage of leaf area damage. This system has been used in screening wheat, barley, and other small grains for insect damage. Hormchong (1967) used a modification of the system developed by Chada et al. (1961) to check sorghum varieties for resistance to the corn earworm and fall armyworm.

A natural population of pest species can not be relied upon every year and a large population of insects must be reared in order to infest the test varieties. With the need for large populations of insects in resistance studies, mass rearing techniques must be used. Many natural food diets have been used for Lepidopterous species (Ellisor 1935, Barber 1936, and Callahan 1962). Although these diets produce healthy larvae, they require a great deal of labor, expense, and the number of insects that can be reared is limited. These and other problems make it necessary to use artificial diets to rear Lepidopterous insects. Artificial diets have been developed by Vanderzant et al. (1962), Adkisson, et al. (1960), Berger (1963), Bailey (1964), and Hormchong (1967). Bailey (1964) and Hormchong (1967) give excellent literature reviews on rearing Lepidopterous insects on artificial diets. Mass rearing techniques were developed by Bailey (1964) and Hormchong (1967)

Infestation procedures for corn and sorghum were developed by Blanchard and Satterthwait (1942) and Bennett and Josephson (1962) in which larvae were placed on plants with a camels hair brush. Hormchong (1967) infested sorghum whorls with paper strips containing fertile eggs.

Some excellent references on general host plant resistance are: Painter (1941, 1951, 1954, 1958, 1960, 1966), Snelling (1941a, 1941b) Dicke (1954, 1963), Beck (1965), Hormchong (1967), and Young (1969).

MATERIALS AND METHODS

In the summer of 1967 a preliminary resistance study was made on 355 varieties of sorghums from India. The aim of this study was to find varieties that possessed resistance to the corn earworm and the fall armyworm. Sorghum varieties showing resistance in this study were selected for future intensive study to obtain resistant germ plasm for use by plant breeders.

The Indian sorghum varieties used in this study were obtained through the cooperation of Purdue University. The 355 sorghum varieties represented many types of sorghums including milos, kafirs, feteritas, kaloiangs, hegaris, sorgos, and other sorghums.

Artificial diet

The artificial diet used had a wheat germ base which was developed by Hormchong (1967) and is shown in Table 1. This diet is a modification of diets developed by Vanderzant et al. (1962), Berger (1963), and Bailey (1964). The diet was used for both the corn earworm and the fall armyworm.

Rearing techniques

The rearing was conducted in the Entomology controlled environment insectary on the Oklahoma State University campus, as

Table 1. Composition of corn earworm and fall armyworm diet.

Constituents	Amount
Wheat Germ	108 g
Sucrose	96 g
Casein (Vitamin Free)	126 g
Salt Mixture (Wesson's)	36 g
Alphacel	18 g
Vitamin Fortification Mixture	36 g
Ascorbic Acid	15 g
Agar	75 g
KOH Solution 22.5%	18 ml
Formaldehyde 10%	15 ml
Methyl Parahydroxyberzoate 15% in 95% Ethyl Alcohol	36 ml
Propionic Acid	5 ml
Tetracycline (250 mg per capsule)	3 capsules
Water	3000 ml

described by Bailey (1964) and Hormchong (1967). Modifications that were necessary for the two insects are described under the following headings.

Larvae- One-oz. clear plastic medicine cups, approximately one-third full of diet, were used as larval rearing chambers. Two first instar corn earworm larvae or three fall armyworm larvae were placed in each cup for the respective studies. Pupation for both species occurred 16 to 20 days after cups were infested.

Emergence chambers- One-gal, round food cartons were used as emergence chambers. Paper toweling was placed on the bottom of the carton, and a petri dish containing 25 pupae was placed in the carton. The toweling was moistened twice a day. Adults emerged 8 to 12 days after pupation. The procedures were the same for both species.

Mating cages- Mating cages for the corn earworm were made by covering 1-gal round food cartons with nylon screen cloth. Fifteen pairs of newly emerged moths were placed in each cage and fed a 10 percent honey solution twice a day.

Fall armyworm mating cages were used as described by Bailey (1964). Twenty-five pairs of newly emerged moths were placed in screen wire mating cages. Wax paper was placed around each cage and eggs were oviposited on the paper. A constant supply of honey solution was provided for the moths.

The corn earworm moths for the 1967 field test and the fall armyworm moths for both tests were kept in the laboratory at approximately 80 F with the humidity varying between 20 and 60 percent. The corn earworm moths for the field 1968 and Greenhouse 1969 tests were stored in a bioclimatic chamber with environmental conditions set at 80 F, above 90 percent humidity, and a 14-hour light period. These conditions were described by Callahan (1962) as being best suited for corn earworm oviposition.

Oviposition and egg storage- Eggs of the corn earworm were deposited on the sides of the cages and on the nylon screening. At 3-day intervals, after oviposition began, the moths were transferred to new cages. Paper towels were placed over the cartons containing the eggs and moistened twice a day. The eggs were allowed to hatch in the carton in which they were oviposited.

The fall armyworm moths oviposited on the wax paper surrounding the mating cages. The wax paper containing the eggs was removed at 2-day intervals and placed in one-gal. round food cartons. Towels were placed over the cartons and moistened twice a day.

Since oviposition occurred over a 7-day period, some means had to be employed to have the eggs hatch at approximately the same time. This problem was solved by storing the eggs in a bioclimatic chamber at temperatures varying from 40 to 60 F (Hormchong 1967). Two days prior to infestation the eggs were moved to a chamber set at 85 F and allowed to hatch. The first instar larvae were transferred from the cartons directly to the sorghum plants. This procedure was used for both species of insects.

For more detailed descriptions of the rearing procedures for the corn earworm and the fall armyworm refer to Bailey (1964) and Hormchong (1967).

Field 1967 corn earworm test

Source of insects- Corn earworm adults were collected from light traps on the Oklahoma State University Entomology farm in September, 1966. The colony was reared by Dr. Hormchong until the test began. The tenth generation larvae were used to infest the sorghum.

Planting procedures- On June 26, 1967, 355 entries of native Indian sorghums were planted on the Agronomy Farm south of the Oklahoma State University water treatment plant. One ten-foot row of each entry was planted. Most of the entries emerged by July 5. The seedlings were thinned to 12 plants per row when approximately 10 days old.

Infesting procedure- On July 24 the whorls of five plants of each entry were infested with ten first instar larvae per plant. The infestation procedure, as described by Blanchard and Satterthwait (1942), was accomplished by using a moistened camels hair brush to place larvae on the plant whorl.

Leaf injury rating - Leaf injury ratings were made on the five infested plants on July 21 and August 7, 14, and 21. August 7 and 14 injury ratings were made on 5 plants (or the number of plants that remained in the row) from each entry that had not been manually infested (check). A rating system of 0-5, as described by Chada et al. (1961) was used. This rating system is shown in Table 2. This system is an estimate of the percent leaf damage. Hormchong (1967) used this classification and found it to be acceptable for sorghum resistance studies.

Field 1968 corn earworm test

Source of insects - Late instar corn earworm larvae were collected from sweet corn gardens in Payne County, Oklahoma, during the period June 5 to June 15. The first generation larvae were used to infest the plants.

Planting procedure - On June 19, 1968, 78 entries of sorghums were planted on the Agronomy Farm south of the Oklahoma State University water treatment plant. All of the entries planted were chosen from the 355 entries tested in the summer of 1967. Seventy-five of the entries planted had leaf damage ratings of 2.0 or less in the 1967 test. Entries 28, 76, and 319 were planted because they had leaf readings of 2.8 or above, and were chosen as susceptible checks. Three replications of each entry were planted in a completely randomized design. The same planting and thinning procedures were used as in

Table 2. Leaf damage rating scale for corn earworm and fall armyworm sorghum resistance studies.

Rating	Percent Damage
0	0-10
1	11-20
2	21-40
3	41-60
4	61-80
5	Beyond Recovery

the 1967 test.

Injury rating - Injury ratings were made July 17, 24, 31, and August 8, 1968 on the manually infested plants. July 24 and 31 injury ratings were taken on 4 plants (or the number of plants remaining in the row) that had not been manually infested (check). The same leaf damage rating system was used as in the 1967 field test.

Greenhouse 1969 corn earworm test

Source of insects - Late instar corn earworm larvae were received from the Biological Control Laboratory, University of Missouri, Columbia, Missouri, November 27, 1968. The third generation larvae were used in the test.

Planting procedure - On February 3, 1969, 16 entries of sorghums were planted in 8-inch flower pots in the greenhouse. Twelve of the entries planted were selected because they possessed leaf damage ratings of 1.5 or below in both the 1967 and 1968 field tests. Two varieties (Martin and T.S. 338) were planted as resistant check varieties (Hormchong 1967). Two varieties (RS 610 and OK 612) were planted as possible susceptible check varieties. These two varieties sustained higher leaf damage in the field in 1968 than did any of the 78 Indian entries planted. However, both the RS 610 and OK 612 varieties were planted at much later dates than the Indian sorghums, and it is not possible to conclude what effect this may have had on the natural infestations on the two varieties.

The pots were arranged in a randomized block design, with two blocks and two replications in each block. Each replication contained four plants.

Infesting procedure - On February 24 five first instar corn earworm larvae were placed on the whorl of each plant. The same infesting procedures were followed as in the field tests.

Injury rating - Injury ratings were made March 3, 10, 17, and 24. The same injury rating system was used as in the field tests.

Field 1967 fall armyworm test

Source of insects - Fall armyworm eggs were received from the Entomology Research Division, Southern Grain Insects Research Laboratory, Coastal Plain Experiment Station, Tifton, Georgia on February 7, 1966. The twelth generation larvae were used to infest the sorghums.

Planting procedure - On June 26, 1967, 355 entries of native Indian sorghums were planted on the Agronomy Farm south of the Oklahoma State University water treatment plant. The same planting procedures were used as in the corn earworm field test. Most entries had emerged by July 4. On July 7 the seedlings were thinned to 12 plants per row.

Infesting procedure - On July 18 ten first instar fall armyworm larvae were placed in the plant whorls of five plants of each entry. The same infestation procedures were followed as in the field corn earworm tests.

Leaf injury rating - Leaf injury ratings on the manually infested plants were made July 25 and August 1, 8, and 14. On August 1 and 8 injury ratings were made on five plants (or the number of plants remaining in the row) that had not been manually infested. The leaf rating system used is shown in Table 2.

Fall armyworm greenhouse tests

Greenhouse resistance studies were conducted on the 355 entries of sorghums during October 23, 1967 to March 31, 1968. The seedling plants were used to check for resistance. Hormchong (1967) found that the fall armyworm would feed on seedling sorghum plants but that the plants must be older for the corn earworm to feed. For this reason extensive greenhouse tests were not attempted for the corn earworm.

Source of insects - The fall armyworm strain used was the same as was used in the 1967 field test. The 15th, 16th, 19th and 20th generation larvae were used in the resistance tests.

Planting procedure - The sorghum varieties were planted in sand benches (8 ft x 4 ft x 5 inch) in the greenhouse. Each entry was planted in rows 24 inches long and 9 inches apart. The entries emerged approximately seven days after planting. Five days after emergence the plants were thinned to 12 per row.

Infesting procedure - Seven days after the plants emerged, two first-instar larvae were placed on each plant following a modified procedure described by Bennett and Josephson (1962). To prevent larval migration from one variety to another a clear, plastic sheet (8 1/2 inches tall) was placed in a vertical position between the entries.

Leaf injury ratings - Leaf injury ratings were made 3 and 5 days after infesting the plants. A rating system of 0-10, based on work by Wiseman, Painter, and Wassom (1966), was used. This rating system is shown in Table 3.

Effects of rearing fall armyworms on artificial diets for varying numbers of generations on feeding damage to sorghums.

To test plants for resistance to insects it is essential to have a large population of insects available. With the use of artificial diets, one question that arises, is will a strain that has been reared on diet for many generations react the same to its host plants as when first placed on diet.

Bailey (1964) reported that the life cycle of armyworms reared on artificial diet was 35.6 days compared to 35 days for armyworms reared on sorghum.

This test compared feeding on sorghums of fall armyworms reared on artificial diet for 15 and 16 generations with armyworms reared on diet for 2 and 3 generations.

Source of insects - The larvae used for the 15 and 16 generations studied were from the strain used for the greenhouse resistance test. The other armyworm strain used was collected in a sorghum

Table 3. Seedling leaf damage rating scale for greenhouse sorghum resistance tests.

Rating	Leaf Damage
0	no visible damage
1	small amount of pinhole-type damage
2	several pinholes
3	small amount of shot-hole type injury with 1 or 2 lesions
4	several shot-hole type injuries and a few lesions
5	several lesions
6	several lesions, shot-hole injury and portions eaten away
7	several lesions and portions eaten away with some areas dying
8	several portions eaten away with area dying
9	the whorl almost or completely eaten away and several lesions with more areas dying
10	plant dead, dying or almost completely destroyed

field near the Entomology Laboratory on August 29, 1967. Moths were collected from sorghum plants and placed in oviposition cages. Eggs were collected and the hatching larvae were placed on diet. The 2 and 3 generations were used to infest the sorghum plants.

Planting and infesting procedure - On October 12, 1967, 12 entries of sorghums from India were planted in sand benches in the greenhouse. Two replications of each entry were planted in 24-inch rows, 9 inches apart. One entry failed to germinate and five more entries failed to have the desired number of plants per row. The other entries were thinned to 12 plants per row a few days after emergence. On October 25, 1967 two first-instar larvae were placed on each plant. To prevent larval migration from one entry to another a clear, plastic sheet (8 1/2-inches tall) was placed in a verticle position between the entries. Injury ratings were made October 28 and 30.

On November 9, 1967 eleven varieties were replanted and the same procedures were followed as in the first test. Seven of the entries failed to have the desired number of plants. The plants were infested November 22 and injury ratings were made November 25 and 28.

Injury ratings - Leaf injury ratings were made 3 and 5 days after infesting. The rating system used is shown in Table 3.

RESULTS AND DISCUSSION

The testing of 355 entries of native Indian sorghums for resistance to corn earworm and fall armyworm attack gave some satisfactory results. Evaluation of varying degrees of resistance was based on leaf injury damage. The data on resistance obtained was difficult to evaluate by statistical analysis. Because of the small number of plants checked and also the fact that sampling procedures were not involved (all plants manually infested were rated), the average leaf damage of the entry was used to determine the resistance or susceptibility of the entry. The differences in reactions of the entries to infestation are shown in tables which follow.

Hormchong (1967) selected a leaf injury rating of 2.0 or below (0-5 rating scale) as showing resistance. This criterion was also used in the mature plant tests. A leaf damage rating of 4.0 or below (0-10 rating scale) was selected as showing resistance in the greenhouse seedling plant studies.

Since corn earworms and fall armyworms pupate 16-20 days after the eggs hatch, the damage ratings taken 14 and 21 days after infestation were used to determine resistance. The fifth day injury ratings were used to determine resistance in the seedling plant studies.

Field 1967 corn earworm test

Many of the entries planted had poor, or no, emergence. Of the 355 entries planted, 114 failed to emerge and 19 had only four plants.

Sorghum entries were selected for future intensive study if the infested and check plants had leaf damage ratings of 2.0 or less (0-5 scale) on both the 14 and 21 day damage ratings. On this basis, 75 of the 241 growing entries showed resistance to corn earworm attack (Table 4). These 75 entries were to be used in future resistance studies.

Thirteen infested entries possessed damage ratings of 1.5 or less. These 13 entries, as indicated by subscript a in Table 4, probably offer the best possibility of finding resistant germ plasm to corn earworm attack and will be examined closely in future studies.

Field 1968 corn earworm test

Seventy-eight entries were selected from the 355 planted in the field in 1967 and were replanted in 1968. Of the 78 entries planted, only one entry failed to emerge but several failed to have the desired number of plants.

The 78 entries planted in the summer of 1968 had lower overall leaf damage ratings following manual infestation than did the same entries in the 1967 test. Table 5 compares the 1967 and the 1968 tests of the 78 entries. The 14-day damage ratings in the 1968 test compares

Table 4. Average corn earworm injury rating of 75 of the 355 field planted Indian sorghums - 1967.

Entry no.	Leaf damage rating (0-5 scale)			
	Manually infested		Check	
	14 Day	21 Day	14 Day	21 Day
8	1.0	1.2[a]	1.0	1.3
12	1.2	2.0	1.0	1.7
24	1.2	1.6	1.2	1.2
34	1.0	1.4[a]	1.0	1.5
35	1.4	1.6	1.0	1.6
36	1.2	2.0	1.0	2.0
39	1.6	2.0	1.6	1.6
48	1.0	2.0	1.3	1.3
52	1.8	2.0	1.3	1.8
53	1.0	1.2[a]	1.0	1.3
56	1.0	1.6	1.0	1.3
57	1.2	1.2[a]	1.0	1.3
60	1.0	1.6	1.0	1.8
61	1.8	2.0	1.6	2.0
65	1.4	1.8	1.3	1.7
69	1.0	1.6	1.4	1.8
71	1.4	2.0	1.8	2.0
72	1.6	1.6	1.3	1.8
87	1.4	1.6	1.5	1.7
88	1.0	1.6	1.4	2.0
94	1.6	2.0	1.0	1.8
95	1.8	1.8	1.8	2.0
96	1.4	1.8	1.2	2.0
115	1.2	1.6	1.0	2.0
116	1.2	1.4[a]	1.7	1.7
118	1.0	1.0[a]	1.8	2.0
129	1.2	1.6	1.0	1.8
130	1.6	2.0	1.0	1.5
131	1.6	2.0	1.0	2.0
132	1.2	1.2[a]	1.0	1.8
134	1.0	2.0	1.0	1.8
136	1.4	1.8	1.0	1.0
139	1.4	1.6	1.3	1.5
142	1.6	1.8	1.0	1.5
164	1.6	2.0	1.2	1.4
165	1.2	1.6	1.0	1.0
166	1.0	1.4	1.4	1.8
167	1.4	2.0	1.0	1.8
174	1.8	2.0	1.2	1.6
184	1.2	1.6	1.0	1.4

Table 4 (Continued)

Entry no.	Leaf damage rating (0-5 scale) Manually infested 14 Day	21 Day	Check 14 Day	21 Day
185	1.8	1.8	.8	1.2
190	1.2	1.4[a]	1.2	1.8
192	1.4	1.8	1.2	1.6
199	1.0	1.6	.6	1.0
201	1.0	2.0	1.0	1.6
204	1.2	2.0	1.0	1.2
207	1.2	1.8	1.0	1.3
208	1.4	1.4[a]	1.2	1.2
211	1.4	2.0	1.2	1.6
212	1.4	1.6	1.4	1.6
229	1.0	2.0	1.2	1.6
238	1.2	1.8	1.0	1.2
242	1.4	2.0	1.0	1.7
244	1.0	1.8	1.5	2.0
245	1.6	1.6	1.5	2.0
246	1.2	2.0	1.4	2.0
247	1.2	1.6	1.5	1.8
260	1.2	1.4[a]	1.0	1.0
265	1.0	1.2[a]	1.0	1.0
268	1.2	1.6	1.4	2.0
272	1.4	1.6	1.0	1.6
273	1.0	1.7	1.0	1.0
283	1.6	2.0	1.2	1.7
286	1.5	1.7	1.2	2.0
288	1.4	1.6	1.2	1.5
304	1.2	1.2[a]	1.0	1.6
305	1.4	1.8	1.0	1.4
308	1.4	1.6	1.0	1.6
309	1.4	2.0	1.5	2.0
310	1.0	1.8	1.0	1.0
313	1.2	1.6	1.2	1.6
325	1.4	2.0	1.2	2.0
331	1.6	2.0	1.3	1.6
334	1.0	1.6	1.0	2.0
338	1.2	1.8	1.0	1.3

a/ Indicates varieties with damage ratings of 1.5 or less.

Table 5.--Average corn earworm damage rating of 78 field planted Indian sorghums - 1967 and 1968.

Entry no.	Leaf damage rating (0-5 scale)							
	1967 Field test				1968 Field test			
	Manually infested		Check		Manually infested		Check	
	14 Days	21 Days	14 Days	21 Days	14 Days	21 Days	14 Days	21 Days
8[ab]	1.0	1.2	1.0	1.3	1.2	1.3	1.1	1.3
12	1.2	2.0	1.0	1.7	1.3	1.8	1.2	1.4
24[a]	1.2	1.6	1.2	1.2	1.5	1.6	1.4	1.4
28	3.0	3.0	2.0	2.8	2.1	2.3	1.5	1.8
34	1.0	1.4	1.0	1.5	1.7	1.5	1.0	1.0
35[a]	1.4	1.6	1.0	1.6	1.3	1.1	1.1	1.1
36	1.2	2.0	1.0	2.0	1.3	1.2	1.2	1.2
39	1.6	2.0	1.6	1.6	1.1	1.1	1.0	1.1
48	1.0	2.0	1.3	1.3	1.4	1.7	1.0	1.0
52	1.8	2.0	1.3	1.8	1.5	1.5	1.0	1.0
53[ab]	1.0	1.2	1.0	1.3	1.0	1.0	1.0	1.0
56[a]	1.0	1.6	1.0	1.0	1.0	1.0	1.1	1.1
57[ab]	1.2	1.2	1.0	1.3	1.1	1.1	1.1	1.1
60[a]	1.0	1.6	1.0	1.8	1.2	1.5	1.4	1.4
61	1.8	2.0	1.6	2.0	1.1	1.1	1.5	1.5
65	1.4	1.8	1.3	1.7	1.1	1.1	1.0	1.0
69[a]	1.0	1.6	1.4	1.8	1.1	1.1	1.1	1.1
71	1.4	2.0	1.8	2.0	1.1	2.3	1.2	1.2
72[a]	1.6	1.6	1.3	1.8	1.1	1.1	1.0	1.0
76	3.0	3.0	2.5	3.0	2.2	2.5	1.2	2.0
87	1.4	1.6	1.5	1.7	1.1	1.1	1.5	1.3
88[a]	1.4	1.6	1.5	1.7	1.1	1.1	1.3	1.3
94	1.6	2.0	1.0	1.8	1.1	1.3	1.3	1.3
95	1.8	1.8	1.8	2.0	1.3	1.3	1.0	1.0

Table 5 (Continued)

Entry no.	Leaf damage rating (0-5 scale)							
	1967 Field test				1968 Field test			
	Manually infested		Check		Manually infested		Check	
	14 Days	21 Days	14 Days	21 Days	14 Days	21 Days	14 Days	21 Days
96	1.4	1.8	1.2	2.0	1.0	1.1	1.1	1.1
115[a]	1.2	1.6	1.0	2.0	1.1	1.1	1.2	1.2
116[a]	1.2	1.4	1.7	1.7	1.3	1.5	1.2	1.2
118[a]	1.0	1.0	1.8	2.0	1.0	1.0	1.1	1.2
129[a]	1.2	1.6	1.0	1.8	1.4	1.5	1.1	1.4
130	1.6	2.0	1.0	1.5	1.3	1.9	1.0	1.0
131	1.6	2.0	1.0	2.0	1.2	1.2	1.0	1.0
132[a]	1.2	1.2	1.0	1.8	1.2	1.1	1.2	1.2
134	1.0	2.0	1.0	1.8	1.3	1.1	1.1	1.1
136	1.4	1.8	1.0	1.0	1.2	2.2	1.2	1.2
139[a]	1.4	1.6	1.3	1.5	1.6	1.6	1.8	1.8
142	1.6	1.8	1.0	1.5	1.2	1.0	---	---
164	1.6	2.0	1.2	1.4	1.4	1.4	1.0	1.0
165[a]	1.2	1.6	1.0	1.0	1.1	1.2	1.2	1.3
166[a]	1.0	1.4	1.4	1.8	1.4	1.3	1.0	1.0
167	1.4	2.0	1.0	1.8	1.2	1.2	1.0	1.0
174	1.8	2.0	1.2	1.6	1.1	1.9	1.0	1.2
184[a]	1.2	1.6	1.0	1.4	1.0	1.0	1.4	1.4
185	1.8	1.8	.8	1.2	1.3	1.1	1.4	1.4
190[a]	1.2	1.4	1.2	1.8	1.2	1.3	1.3	1.3
199[a]	1.0	1.6	.6	1.0	1.5	1.3	1.1	1.1
201	1.0	2.0	1.0	1.6	1.3	1.3	1.0	1.0
204	1.2	2.0	1.0	1.2	1.3	1.2	1.0	1.0

Table 5 (Continued)

Entry no.	Leaf damage rating (0-5 scale) 1967 Field test: Manually infested 14 Days	21 Days	Check 14 Days	21 Days	1968 Field test: Manually infested 14 Days	21 Days	Check 14 Days	21 Days
207	1.2	1.8	1.0	1.3	1.2	1.1	1.1	1.1
208[ab]	1.4	1.4	1.2	1.2	1.1	1.2	1.0	1.0
211	1.4	2.0	1.2	1.6	1.1	1.4	1.0	1.0
212[a]	1.4	1.6	1.4	1.6	1.0	1.0	1.0	1.0
229	1.0	2.0	1.2	1.6	1.3	2.4	1.0	1.1
238	1.2	1.8	1.0	1.2	1.0	1.0	1.2	1.2
242	1.4	2.0	1.0	1.7	1.4	1.3	1.1	1.2
244	1.0	1.8	1.5	2.0	1.1	1.3	1.1	1.1
245[a]	1.6	1.6	1.5	2.0	1.3	1.2	1.2	1.2
246	1.2	2.0	1.4	2.0	1.0	1.0	1.0	1.1
247[a]	1.2	1.6	1.5	1.8	1.0	1.1	1.2	1.2
260[ab]	1.2	1.4	1.0	1.0	1.0	1.0	1.0	1.0
265[ab]	1.0	1.2	1.0	1.0	1.2	1.3	1.1	1.1
268[a]	1.2	1.6	1.4	2.0	1.5	1.4	1.6	1.6
272[a]	1.4	1.6	1.0	1.6	1.1	1.0	1.0	1.0
273	1.0	1.7	1.0	1.0	1.0	1.0	1.0	1.0
283	1.6	2.0	1.2	1.7	1.3	1.1	1.0	1.0
286	1.5	1.7	1.2	2.0	1.6	1.9	1.3	1.3
288[a]	1.4	1.6	1.2	1.5	1.1	1.3	1.0	1.4
304[a]	1.2	1.2	1.0	1.6	1.2	1.0	1.1	1.1
305	1.4	1.8	1.0	1.4	1.0	1.9	1.0	1.0
308[a]	1.4	1.6	1.0	1.6	1.3	1.4	1.0	1.0
309	1.4	2.0	1.5	2.0	1.4	1.3	1.0	1.0
310	1.0	1.8	1.0	1.0	1.0	2.1	1.0	1.3

Table 5 (Continued)

Entry no.	Leaf damage rating (0-5 scale) 1967 Field test Manually infested 14 Days	21 Days	Check 14 Days	21 Days	1968 Field test Manually infested 14 Days	21 Days	Check 14 Days	21 Days
313[a]	1.3	1.6	1.2	1.6	1.1	1.0	1.1	1.2
319	3.0	3.0	1.6	2.8	1.4	2.0	1.1	1.4
325	1.4	2.0	1.2	2.0	1.3	2.2	1.2	1.2
331	1.6	2.0	1.3	1.6	1.4	1.7	1.2	1.4
334	1.0	1.6	1.0	2.0	---	---	---	---
338	1.2	1.8	1.0	1.3	1.0	1.0	1.0	1.0

a/ Indicates sorghum entries selected for future resistance studies.

b/ Indicates sorghum entries with leaf damage ratings of 1.4 or less.

favorably with the 1967 test but, the 21-day damage ratings for 1968 differ considerably from the 1967 test. The majority of the entries in the 1968 test fall in the damage rating range of 1.0 to 1.4. This differs from the 1967 test in that most of the entries in 1967 fall in the damage rating range of 1.6 to 2.0. The large natural population of corn earworms in the 1967 test and the large number of parasites and predators in 1968 might account for the differences in reactions of the entries.

The three entries (28, 76, and 319) planted as susceptible checks in 1968 had higher leaf damage ratings than most of the entries showing resistance in 1967, but did not show as high leaf damage as they did in 1967. Of the 75 entries planted having a damage rating of 2.0 or less in 1967, only six (71, 136, 192, 229, 310, and 325) had damage ratings of above 2.0 (Table 5).

From this study, entries with damage ratings of 1.6 or less for both the 1967 and 1968 tests were saved for future intensive resistance studies. Of the 75 entries studied, 33 had average damage ratings of 1.6 or less, as indicated by subscript a in Table 5. Six entries (8, 53, 57, 208, 260, and 265), as shown by subscript b in Table 5, had damage ratings of 1.4 or less on both infested and check plants in the 1967 and 1968 tests. From the tests conducted, these six entries probably offer the best possibility of finding resistant germ plasm to corn earworm attack and therefore, will be examined closely in future tests.

Greenhouse 1969 corn earworm test

Since two varieties (OK 612 and RS 610) planted as susceptible check varieties showed very little leaf damage, it is difficult to evaluate this test. Martin and T. S. 338, selected as resistant check varieties, had ratings of 0.9 and 0.8, which were the lowest damage in the test. Hormchong (1967) reported that these entries had leaf damage ratings of 1.0 on the 14-day damage ratings.

The 12 entries planted which had leaf damage ratings of 1.5 or below in the 1967 and 1968 tests, received damage ratings comparable to their 1967 and 1968 ratings (Table 6). Only one entry (No. 53) received a damage rating of above 1.5, and it was only 1.6.

From this test and the 1967 and 1968 tests, the five entries (Nos. 8, 57, 208, 260, and 265), as indicated by subscript a in Table 6, probably offer the best possibility of resistant germ plasm to corn earworm attack. However, all 12 entries showed little leaf damage in all tests conducted.

Field 1967 fall armyworm test

Of the 355 Indian sorghums planted, 67 entries failed to emerge and 24 entries only had four plants.

Sorghum entries were selected for future intensive studies if the infested and check plants had leaf damage ratings of 2.0 or less (0-5 scale) on both the 14 and 21-day damage ratings. On this basis, 93 entries were selected for future study (Table 7). Seventeen of the

Table 6. Average corn earworm damage ratings on 16 greenhouse planted sorghums as compared to the 1967 and 1968 field tests - 1969.

Entry no.	Leaf damage rating (0-5 scale)					
	Greenhouse test		1967 Field test		1968 Field test	
	14 Days	21 Days	14 Days	21 Days	14 Days	21 Days
8[a]	1.1	1.2	1.0	1.2	1.2	1.3
53	1.0	1.6	1.0	1.2	1.0	1.0
57[a]	1.0	1.4	1.2	1.2	1.1	1.1
116	1.1	1.3	1.2	1.4	1.3	1.5
118	1.0	1.1	1.0	1.0	1.0	1.0
132	1.0	1.3	1.2	1.2	1.2	1.1
166	1.1	1.4	1.0	1.4	1.4	1.3
190	1.0	1.3	1.2	1.4	1.2	1.3
208[a]	1.3	1.4	1.4	1.4	1.1	1.2
260[a]	1.0	1.1	1.2	1.4	1.0	1.0
265[a]	1.0	1.2	1.0	1.2	1.2	1.3
304	1.0	1.1	1.2	1.2	1.2	1.0
OK 612	1.2	1.4				
RS 610	1.0	1.4				
Martin	.9	1.0				
TS 338	.8	.9				

a/ Indicates entries showing highest degree of resistance in all tests conducted.

Table 7. Average fall armyworm damage rating of 93 of the 355 field planted Indian sorghums- 1967.

Entry no.	Leaf damage rating (0-5 scale) Manually infested plants 14 Days	21 Days	Check plants 14 Days	21 Days
8	1.2	1.2[a]	.4	.6
9	1.2	1.6	.6	.6
10	1.8	1.6	.6	.8
12	1.4	1.4[a]	.6	.8
14	2.0	2.0	1.0	1.3
21	1.4	1.6	1.0	1.2
23	1.4	1.4[a]	.4	.4
24	1.4	1.4	1.2	1.6
28	1.4	1.6	1.0	1.2
33	1.2	1.6	1.0	1.0
34	1.0	1.0[a]	.4	1.0
35	1.2	1.2[a]	.6	.8
36	1.6	1.4	1.2	2.0
46	1.4	1.6	1.0	1.2
47	2.0	1.8	1.0	1.4
49	1.2	1.2[a]	1.2	1.4
60	1.8	1.8	1.0	1.0
62	1.0	1.2	1.0	1.6
65	1.6	1.6	1.0	1.2
71	1.6	1.6	1.5	1.7
72	1.6	1.6	.6	1.0
79	2.0	2.0	1.0	1.2
85	1.4	2.0	1.0	1.0
86	1.0	1.4[a]	1.0	1.5
87	1.6	2.0	1.0	2.0
91	1.4	2.0	1.0	1.0
94	1.4	1.4[a]	1.3	1.4
95	1.2	1.6	1.0	1.0
96	1.2	1.6	2.0	2.3
102	1.4	1.4[a]	1.0	1.2
103	1.0	1.6	1.0	1.2
104	1.0	1.6	1.2	1.2
110	1.2	1.4[a]	1.0	1.3
112	1.6	2.0	1.3	1.6
115	1.4	1.8	.8	.8
116	2.0	2.0	.6	1.0
117	1.0	1.8	1.0	1.0
118	1.4	1.8	1.0	1.0
124	1.2	2.0	1.0	1.2

Table 7 (Continued)

Entry no.	Leaf damage rating (0-5 scale)			
	Manually infested plants		Check plants	
	14 Days	21 Days	14 Days	21 Days
129	1.8	1.8	1.0	1.0
130	1.2	1.2[a]	1.0	1.0
134	1.9	2.0	1.2	1.4
135	1.0	1.0[a]	.8	.8
137	1.4	1.8	1.0	1.5
139	1.6	1.6	1.2	1.5
143	2.0	2.0	1.0	1.0
147	1.8	1.8	1.7	1.8
151	2.0	2.0	.8	.8
157	1.8	1.8	1.2	1.4
158	1.8	2.0	1.2	1.5
159	1.6	2.0	1.0	1.2
161	2.0	2.0	1.0	1.3
165	1.8	1.8	1.0	1.0
166	1.2	1.4[a]	.4	.8
176	1.4	2.0	1.0	1.2
177	1.6	2.0	1.0	1.2
182	1.0	1.4[a]	1.0	1.4
184	1.2	1.8	1.3	1.6
185	1.8	2.0	.6	1.0
191	1.8	2.0	1.5	2.0
195	1.4	2.0	1.0	1.2
200	1.4	2.0	1.0	1.2
205	1.8	1.8	1.0	1.0
207	1.4	2.0	1.2	1.5
208	1.6	1.6	.8	1.0
213	1.8	2.0	1.0	1.4
217	1.6	1.8	1.0	1.3
222	1.0	1.5[a]	1.0	1.5
224	1.2	2.0	1.5	1.7
226	1.8	2.0	1.4	1.6
228	2.0	2.0	1.0	1.2
229	1.4	2.0	1.0	1.2
237	1.6	2.0	.8	1.0
240	1.6	2.0	1.0	1.2
241	1.6	2.0	.8	1.0
244	1.2	2.0	1.0	1.0
257	1.4	2.0	1.0	1.0
259	1.4	1.4[a]	1.0	1.2
260	1.4	1.6	.6	1.0

Table 7 (Continued)

Entry no.	Leaf damage rating (0-5 scale) Manually infested plants		Check plants	
	14 Days	21 Days	14 Days	21 Days
265	1.4	1.4	1.4	1.6
273	1.4	2.0	1.0	1.3
313	1.0	1.4[a]	.7	.7
317	1.4	2.0	1.3	1.3
321	2.0	2.0	.2	.2
325	1.4	1.9	.4	.8
326	1.8	2.0	.6	1.0
331	1.8	2.0	1.3	1.4
332	1.2	1.6	1.0	1.2
338	1.8	2.0	.5	.7
342	1.2	2.0	1.0	1.3
348	1.4	1.8	.6	.6
349	1.7	2.0	1.0	1.5
353	1.2	2.0	1.0	1.5

a/ Indicates entries with leaf damage rating of 1.5 or less.

93 entries showed a high degree of resistance (having damage ratings of 1.5 or less), as indicated by subscript a in Table 7. These 17 entries probably offer the best possibility of resistant germ plasm and will be examined closely in future studies.

Greenhouse fall armyworm tests

Of the 355 entries planted in the greenhouse, 37 failed to emerge and 194 failed to have the desired number of plants.

The 93 entries showing resistance in the 1967 field test displayed a higher and wider range of damage ratings in the greenhouse tests. Of the 93 entries, 19 had damage ratings of 4.0 or less, 33 had 5.0 or less, and 53 had 6.0 or less based on the 0-10 scale. Forty of the 93 entries had damage ratings from 6.1 to 9.0. This represents a very large departure from the reactions shown by the same entries in the 1967 field. If the 1967 field test gives accurate indications of the resistance or susceptibility ratings of the entries, the greenhouse tests indicates a need for raising the leaf damage index of resistance to a value higher than 4.0 (0-10 scale) for seedling plant studies. The absence of parasites and predators or other means of natural control might account for higher leaf damage in the greenhouse, but further studies must be conducted before a conclusion can be reached.

From the field test and the greenhouse tests, 19 entries were selected for future intensive study (Table 8). The entries were selected if they possessed leaf damage ratings of 2.0 or less

Table 8. Damage ratings of 19 entries of 355 field and greenhouse planted Indian sorghums having the least leaf injury to fall armyworms - 1968.

Entry no.	Leaf damage rating			
	Field 1967 test (0-5 rating scale) Infested plant rating		Greenhouse tests (0-10 rating scale) Infested plant rating	
	14 Days	21 Days	3 Days	5 Days
7	2.0	2.0	2.8	3.5
8[a]	1.2	1.2	3.3	4.0
21	1.4	1.6	2.7	3.9
23[a]	1.4	1.4	2.6	3.1
24	1.4	1.4	2.8	3.2
26	2.0	1.6	1.9	2.8
28	1.4	1.6	2.6	3.4
33	1.2	1.6	2.2	2.9
34[a]	1.0	1.0	2.1	2.9
35[a]	1.2	1.2	1.6	2.2
38	2.0	2.0	2.1	3.2
46	1.4	1.6	2.5	3.6
47	2.0	1.8	2.0	3.8
48	1.6	2.0	2.4	3.7
49[a]	1.2	1.2	2.5	3.3
60	1.8	1.8	2.7	3.8
71	1.6	1.6	2.5	3.3
72	1.6	1.6	2.8	4.0
182[a]	1.0	1.4	3.2	3.8

a/ Indicates entries showing the highest degree of resistance in the field and greenhouse tests.

(0-5 scale) in the field test and 4.0 or less (0-10 scale) in the greenhouse tests.

The 17 entries with leaf damage ratings of 1.5 or less in 1967, had higher leaf damage, in most cases, in the greenhouse studies also. Six entries had ratings of 4.0 or less, 2 had ratings of 5.0 or less, 1 entry had a rating of 5.2, and 1 entry failed to emerge. The remaining 7 entries had ratings ranging from 7.4 to 9.0. The 6 entries (8, 23, 34, 35, 49, and 182) with ratings of 1.5 or below in the field test and 4.0 or less in the greenhouse seedling tests probably offer the best possibilities of resistant germ plasm to fall armyworm attack. These are indicated by subscript a in Table 8.

<u>Feeding damage to sorghums by fall armyworms reared on artificial diets for varying numbers of generations.</u>

The 5-day injury reading was used to analyze the test. The two strains were analyzed as a paired experiment, as outlined by Steel and Torrie (1960). In this analysis, t calculated for the October test was .5819; for the November test it was .9396. In both cases t tabulated is 2.228 at the 95 percent confidence interval. This analysis shows that there were no significant differences between damage ratings for the 2 and 15 generation fall armyworms in the October test and the 3 and 15 generations in the November test, since t calculated in both cases was smaller than t tabulated. The October test showed less leaf injury than the November test, as shown in Table 9.

Table 9. Feeding damage to sorghums by fall armyworms reared for varying numbers of generations on artificial diet.

Entry no.	Damage ratings			
	October test		November test	
	2 generations	15 generations	3 generations	16 generations
73	4.4	4.4	5.3	6.3
74	5.0	3.8	7.0	5.7
75	5.3	5.2	6.0	8.0
76	4.3	5.6	6.9	6.0
77	4.0	4.7	6.1	6.3
78	6.0	5.0	7.5	7.3
79	5.6	5.4	9.5	6.3
81	4.5	4.6	6.4	6.8
82	4.8	4.8	7.9	7.5
83	4.4	5.1	7.1	6.7
84	4.0	5.0	7.4	7.3
Average	4.7	4.9	7.0	6.7

In both tests the analysis shows no significant differences between the feeding damage of the strain reared for many generations and the strain reared for only two or three generations on diets.

SUMMARY AND CONCLUSIONS

Of 355 entries of native Indian sorghums tested, 33 entries were selected for future corn earworm resistance studies and 19 for fall armyworm studies on the basis of resistance reaction in the tests. Five of the 33 corn earworm-resistant entries (8, 57, 208, 260, and 265) deserve careful future examination because of the low degree of leaf damage sustained in all tests conducted. Six entries (8, 23, 34, 35, 49 and 182) have shown consistently low damage ratings to fall armyworm attack. These 11 entries offer the best possibilities of resistant germ plasm to the corn earworm and fall armyworm. Only 1 entry (8) was found with a high degree of resistance to both the corn earworm and the fall armyworm.

In the 1967 corn earworm field test, the check plants had damage ratings of approximately the same magnitude as the manually infested plants. The fall armyworm test, which was planted in the same field, had very little leaf damage on the check plants. Perhaps many of the corn earworm larvae migrated to the uninfested plants. If this is correct, in future tests the plants should be spaced further apart, and possibly fewer larvae should be placed on each plant. The major problem in corn earworm resistance studies is the large population of insects that are required to infest the plants. If fewer larvae per plant were adequate, the number of entries that could be tested in one season could be greatly increased. However, more work must be conducted before a conclusion can be reached because the 1968 corn earworm field test had low damage ratings on the check plants.

The greenhouse fall armyworm tests showed higher leaf damage ratings than the same entries in the field test. Further work needs to be conducted on fall armyworm greenhouse seedling plant studies.

Since the fall armyworm feeding tests showed no differences in feeding of the two armyworm strains reared on diet for different periods of time, this indicates that continuous rearing on diet appears to be feasible. It is easier to raise the same strain of armyworm continuously on diet than to introduce new specimens each year. When wild armyworms are introduced into the laboratory the possibility of disease is greatly increased. Future tests of this nature need to be conducted for both the fall armyworm and corn earworm.

While resistance to the corn earworm and fall armyworm was observed in testing the 355 sorghum entries from India, the present data obtained are not considered to be of enough reliance to warrant submitting them to plant breeders for use in a resistance breeding program. However, resistance studies techniques have been improved as a result of this study, and with further work, especially with regard to control of natural infestations in untreated check plants, it is believed that entries with significant resistance will be available. It is suggested that this study be continued.

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