EFFECT OF SELFING BAGS AND INSECTICIDES ON INSECT CONTROL AND SOME PLANT TRAITS IN SORGHUM

By

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TRAITS IN SORGHUM

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CHAPTER I

INTRODUCTION

In any sorghum breeding program, it is often necessary to ensure self-fertilization of individual panicles by enclosing those panicles in paper bags.

Grain sorghum (*Sorghum bicolor* (L.) Moench) is one of the most widely grown warm season crops in the United States, and when the panicles are covered with paper bags at flowering time, the warm and humid conditions that develop within the bags are extremely favorable for the development of corn earworm (*Heliothis zea* (Boddie)), corn leaf aphid (*Rhopalosiphum maidis* (Fitch)). Some measures for controlling these problems need to be taken, because the damage caused by them can be severe.

In this study six insecticides in different dosages and combinations were tested on three varieties. The treatments were designed to determine the effect of selfing bags and insecticides on insect control and on some of the most important plant traits in sorghum.

CHAPTER II

REVIEW OF LITERATURE

Sorghum plants have perfect flowers, and they are easily selfed by placing a paper bag over their panicles after they emerge (Quinby and Schertz, 1970) from the leaf sheaths but before any florets open. Such a bag can be left on the panicle until the seed is mature, or it may be removed after flowering is complete. Insects that hatch under the bags are protected from attack by predators. As a result they may destroy most of the kernels on a selfed head.

Corn earworm (Heliothis zea (Boddie) is one of the most destructive insects in sorghum selfing panicles. Moths lay eggs in the panicles (Doggett, 1970). Then small larvae hollow out the kernels, and as they grow, they consume entire kernels. Heavy infestations can strip heads. This insect prefers compact sorghum panicles to open type panicles. Control measures are generally profitable when worms average 2 or 3 per panicle.

Another harmful insect in sorghum selfing panicles is the corn leaf aphid (Rhopalosiphum maidis (Fitch)). It is a cosmopolitan specie. It has been recorded as a pest of sugarcane and grasses in addition to maize and sorghum (Jotwani and Young, 1972). Heavy attacks turn the plants a bronze color, and may prevent panicles from emerging; molds and fungi generally follow on the panicle. Heavy secretions of honeydew attract corn earworm moths. Research shows chemical controls are profitable only if infestations are heavy.

Preliminary tests in 1947 and 1948 (Dahms et al., 1951) indicated that several insecticides used in treated bags killed the corn earworm but permitted an increase of corn leaf aphids. Other materials killed both insects but caused a high degree of sterility. After 12 insecticides had been tested in more than 50 different combinations and concentrations, aldrin was found to be the most satisfactory for the purposes. None of them checked the fungi.

Later, Dahms et al., (1955), by using several insecticides and methods of treating sorghum selfing bags for insect control, concluded that some insecticides gave satisfactory control when the selfing bags were dusted on the inside or when the panicles were dusted or sprayed just before bagging. However since these methods were not practical, most of the tests were made by impregnating the bags with emulsions. DDT, when impregnated at the rate of 133 mg or above per bag, gave excellent control of the corn earworm, but caused an increase in corn leaf aphids. Heptachlor, aldrin, dieldrin, lindane and metacide also gave good corn earworm control. Toxaphene gave satisfactory corn earworm control when applied at 290 mg or above per bag. BHC, lindane, heptachlor, aldrin, TEPP and demeton gave satisfactory corn leaf aphid control; however, both BHC and lindane caused high sterility. Aldrin and heptachlor gave satisfactory control of both insects and caused little sterility. Aldrin gave fair control of the corn leaf aphid and excellent control of the corn earworm when applied as a streak on the inside of the bags at 72 mg per bag.

After study of larval infestations of the corn earworm in sorghum panicles Burkhardt and Breithaupt (1955), indicated that 25 to 30% of the kernels in a sorghum panicle may be damaged or destroyed by 16 larvae/panicle. Burkhardt (1957) found that losses in some sorghum fields varied from 10 to 25% when panicles averaged 1-2 larvae each and stated that 2-3 larvai/panicle constituted an economically damaging infestation. In more accurate studies with corn earworm larvae caged on sorghum panicles it was found (Buckley and Burkhardt, 1962) that one larvae/panicle damaged 6% of the kernels, that the number of kernels damaged by each larvae decreased as the population increased, and that 13 larvae/panicle caused a loss of 48% of the kernels.

Methods of measuring injury of corn by corn earworm have usually involved a function of damage to the ear, as determined by visual or mechanical means (Poole, 1934). Classes of 0 through 5 were used (Wadley, 1949) to evaluate damage. He also used a weighting system of the classes to obtain an estimate of the number of kernels damaged.

Henderson et al. (1965) tested 12 insecticides to control corn earworm of sorghum in Payne and Noble Counties of Oklahoma. The best control was given by carbaryl, DDT, mevimplos, telodrin and naled. The percentage of small larvae in the populations receiving treatment had considerable effect on the degree of control. At the dosage used carbaryl residues on grain and forage were well within the acceptable tolerances.

Chemical control studies of corn leaf aphid (Burkhardt, 1955) have shown that endrin, malathion and lindane gave excellent control of corn leaf aphids in sorghum panicles. Of 21 insecticides tested by Henderson et al. (1964) for control of the corn leaf aphid infested sorghum panicles the most effective were granular formulations of phorate, di-syston telodrin, and endosulfan. When the same chemicals were used in both spray and granular formations, the latter treatments were much more effective because of the deeper penetration of the insecticides into the panicles where the aphids feed. Cate et al. (1973) found that low population densities of corn leaf aphid did not affect grain yield. Wilde and Ohiagu (1976) determined that the control of corn leaf aphid did not significantly increase yield in 9 studies with populations of 800-1500 aphids/plant and in one test involving 3500 aphids/plant.

Hayes (1922) reported that in heavily infested panicles the grain is badly shriveled and its germinative power is affected. He found from several thousand germination tests that the percentage of germination was very low in check plots. Guthrie (1951) found that any insecticide used for treating bags to control corn leaf aphid and corn earworm on bagged sorghum panicles was harmful to the germinative power of the sorghum grain.

CHAPTER III

MATERIALS AND METHODS

This experiment was conducted at the Perkins Agronomy Research Station of the Oklahoma Agricultural Experiment Station from June to October 1979. Eleven treatments including checks were applied to three sorghum varieties: Redlan, OK 632, and Frontier 412 R. Frontier 412 R will be referred to hereafter as Frontier. The treatments involved the use of six insecticides in different dosages and combinations, on sorghum selfing bags. The insecticides used and the combinations and dosages applied to the bags or panicles may be found in Tables I and II. The treated sorghum selfing bags were used to cover the panicles of randomly selected plants in each test plot. The panicles were covered the day before anthesis began. The bags were allowed to remain on the panicles until harvest, between 35 to 50 days, a procedure regularly used to ensure self fertilization in the breeding program.

The treatments were designed to evaluate the control of corn earworm (*Heliothis zea* (Boddie)) and corn leaf aphid (*Rhopalosiphum maidis* (Fitch)). Phytotoxic effects (sterility) were recorded also. The scale used for recording insect injury may be found in Table III. Combinations of insecticides were often used since a single material may be recommended for only one insect. The combinations of carbaryl plus pirimicarb and carbaryl plus lindane were dusted into the bags,

TABLE I

INSECTICIDES USED IN THE EXPERIMENT

Common Name	Chemical Name	Concentration (%)	Formulation
Carbaryl (Sevin)	1 - Naphthyl N - methylcarbamate	50.0	Flowable
Lindane	Gamma isomer of benzene hexachloride	6.0	Dust
Toxaphene	Technical chlorinated camphene	60.0	Emulsifiable concentrate
Methomyl (Nudrin)	5 - methyl N - [(methylcarbamoyl) Oxy] thioacetimidate	24.1	Emulsifiable concentrate
Permethrin (Ambush)	(3 - phenoxyphenil) methyl (±)cis, trans-3-(2, 2-dichloroethenyl)-2, 2-dimethylcyclopro-pane-carboxilate	23.g	Emulsifiable concentrate
Prirmicarb (pirimor)	2(dimethylamino)-5, 6-dimethyl-4-pirymidinyl dimethylcarbamate	50.0	Wettable powder

TABLE II

TREATMENTS AND DOSAGES OF INSECTICIDES USED
IN THE EXPERIMENT

	Treatment		Active Ingredient per Bag	Method of Application
1.	No bags (check)		———	———
2.	Untreated bags		———	———
3.	Treated bags:	Carbaryl + pirimicarb	15 mg + 25 mg	Dusting
4.		Carbaryl + pirimicarb	15 mg + 50 mg	Dusting
5.		Carbaryl + lindane	15 mg + 45 mg	Dusting
6.		Toxaphene + pirimicarb	174 mg + 25 mg	Dipping
7.		Toxaphene + pirimicarb	174 mg + 50 mg	Dipping
8.		Methomyl	48.2 ml	Injecting
9.		Methomyl	24.1 ml	Injecting
10.		Permethrin	47.8 ml	Injecting
11.		Permethrin	23.9 ml	Injecting

TABLE III

DESCRIPTIONS OF SCALES USED FOR
MEASURING INSECT INJURY
ON SORGHUM PANICLES

Scale	Corn Leaf Aphid Incidence	Corn Earworm Injury
1.	None, no exuviate	None, no frass
2.	1 - 10 aphids or exuviate	1 worm present or small amount of frass. Less than 5% of kernel damage.
3.	10 - 50 aphids or exuviate	1 worm present, moderate amount of frass. 6 - 20% of kernel damage.
4.	50 - 200 aphids or exuviate. Some honeydew.	2 worms present, large amount of frass. 21 - 40% of kernel injury
5.	Aphids or exuviate throughout the panicle. Much honeydew	More than 2 worms present, large amount of frass. 41 - 80% of kernel damage.
6.	Panicle a solid mass of aphids, exuviate and honey dew.	More than 2 worms present, large amount of frass. More than 80% kernel damage.

while toxaphene plus pirimicarb was impregnated into the bags by dipping them in an aqueous mixture of the insecticides. They were then allowed to dry before use. The insecticides methomyl and permethrin were sprayed directly on the panicles 10 days after anthesis under untreated bags which had been put on prior to blooming.

The experimental design used was a randomized complete block. Both, treatments and varieties had factorial arrangement in the field and they were 3 times replicated. Each experimental unit was a single row, 25 feet long with approximately 50 plants. Standard agronomic practices for the Oklahoma State University sorghum breeding program were followed as to thinning, cultivation, irrigation, and fertilization.

The sampling procedure consisted of selecting at random 12 panicles from each replication just prior to anthesis. Only 10 panicles were saved for evaluation. Each panicle was carefully examined for the presence of corn leaf aphid, damage from corn earworm, and sterility due to phytotoxic effects.

To record rates of damage caused by insects a scale of 1 to 6 (See Table III) rather than 0 to 5 (Dahms et al., 1955) was used in order to have numerical data suitable for statistical analysis. In some cases there may be some confounding of the effects of corn earworm and phytotoxicity of the insecticides. Sterility was estimated visually as a percentage of undeveloped spikelets.

The application of the insecticides was made in three ways: dusting inside the bags, impregnating the bags with an emulsion, and spraying directly into the panicles. Although the effects of the three methods were not considered, the relative effectiveness of the different chemical products was observed.

When the sorghum panicles reached maturity each of them was harvested, rated, and then weighed individually. The panicles were threshed and the grain was weighed. Both panicle weights and grain weights were recorded. Later 100 kernels from each sample (panicles) were weighed and recorded.

To determine the combined effect of the bags, insects, and chemical products on the seed germination, two out of the ten samples were selected from each replication at random. One hundred kernels were put in an official germination chamber under standard sorghum germination conditions and counted after seven days.

The experiment was analyzed as a randomized complete block design for each of the variables in the study. The effectiveness of each treatment was determined by comparison of the F values obtained from the analysis of variance, and the application of Duncan's Multiple Range test of the means. Tables and figures were constructed to display the distribution of the results obtained.

CHAPTER IV

RESULTS AND DISCUSSION

Corn Leaf Aphid Incidence

In Table IV and Figure 1 may be found the means and distribution of the treatments for corn leaf aphid damage incidence scores. The analysis of variance in Table V showed highly significant differences among treatments and varieties. The variety X treatment interaction was nonsignificant indicating that the three varieties tested reacted similarly to the treatments. Therefore only treatment means will be discussed. This similarity of variety means can be observed in Figure 2.

At the dosages tested, the combination of carbaryl plus pirimicarb at rates of 15 plus 25 mg and 15 plus 50 mg of toxicant per bag gave the most effective control against corn leaf aphid with mean indices of 1.13 and 1.07, respectively. They were significantly better than treatments 5, 6, 10, 11, and 2. Permethrin at dosages of 23.9 and 47.8 ml of toxicant per panicle was least efficient with mean indices of 3.21 and 2.91, respectively. These treatments were significantly less effective than treatments 5, 8, 7, 9, 3 and 4.

Treatments 1 and 2 gave extremely different results, wherein treatment 1 (no bags) showed practically no corn leaf aphid incidence and treatment 2 (untreated bags) gave the highest level of infestation

TABLE IV

MEANS FOR CORN LEAF APHID INCIDENCE SCORES

Treatment	Variety: Frontier	Redlan	OK 632	Mean	Duncan's Range*
2	5.07	3.30	3.00	3.78	A
11	3.63	3.06	2.93	3.21	AB
10	3.43	2.63	2.67	2.91	B
6	2.77	2.43	2.53	2.58	BC
5	3.00	1.70	1.50	2.07	C
8	2.37	1.83	1.43	1.88	CD
7	2.33	1.93	1.30	1.86	CD
9	3.03	1.40	1.13	1.86	CD
3	1.00	1.23	1.17	1.13	DE
4	1.00	1.10	1.10	1.07	E
1	1.00	1.00	1.00	1.00	E
Mean	2.60	1.96	1.79	2.12	
Duncan's Range*	A	B	B		

*Significance level: 5%

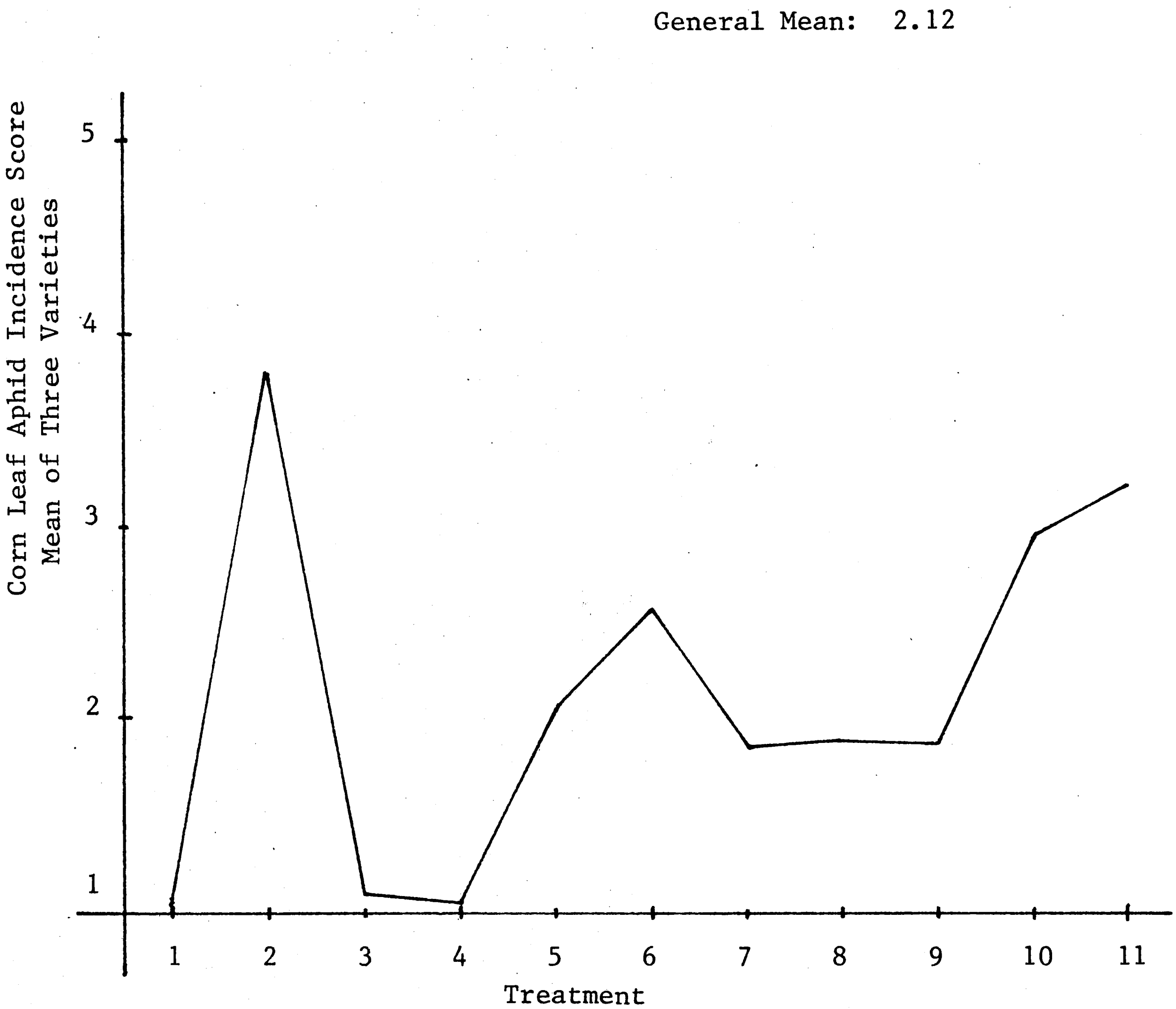

Figure 1. Distribution of the Means for Corn Leaf Aphid Incidence Scores

TABLE V

ANALYSIS OF VARIANCE FOR CORN LEAF APHID INCIDENCE SCORES

Source	DF	MS	F Value
TOTAL	98		
REPLICATION	2	0.960	1.63
VARIETY	2	5.960	10.10**
TREATMENT	10	7.515	12.74**
VARIETY X TREATMENT	20	0.559	0.95
ERROR	64	0.590	

**Significance level: 1%

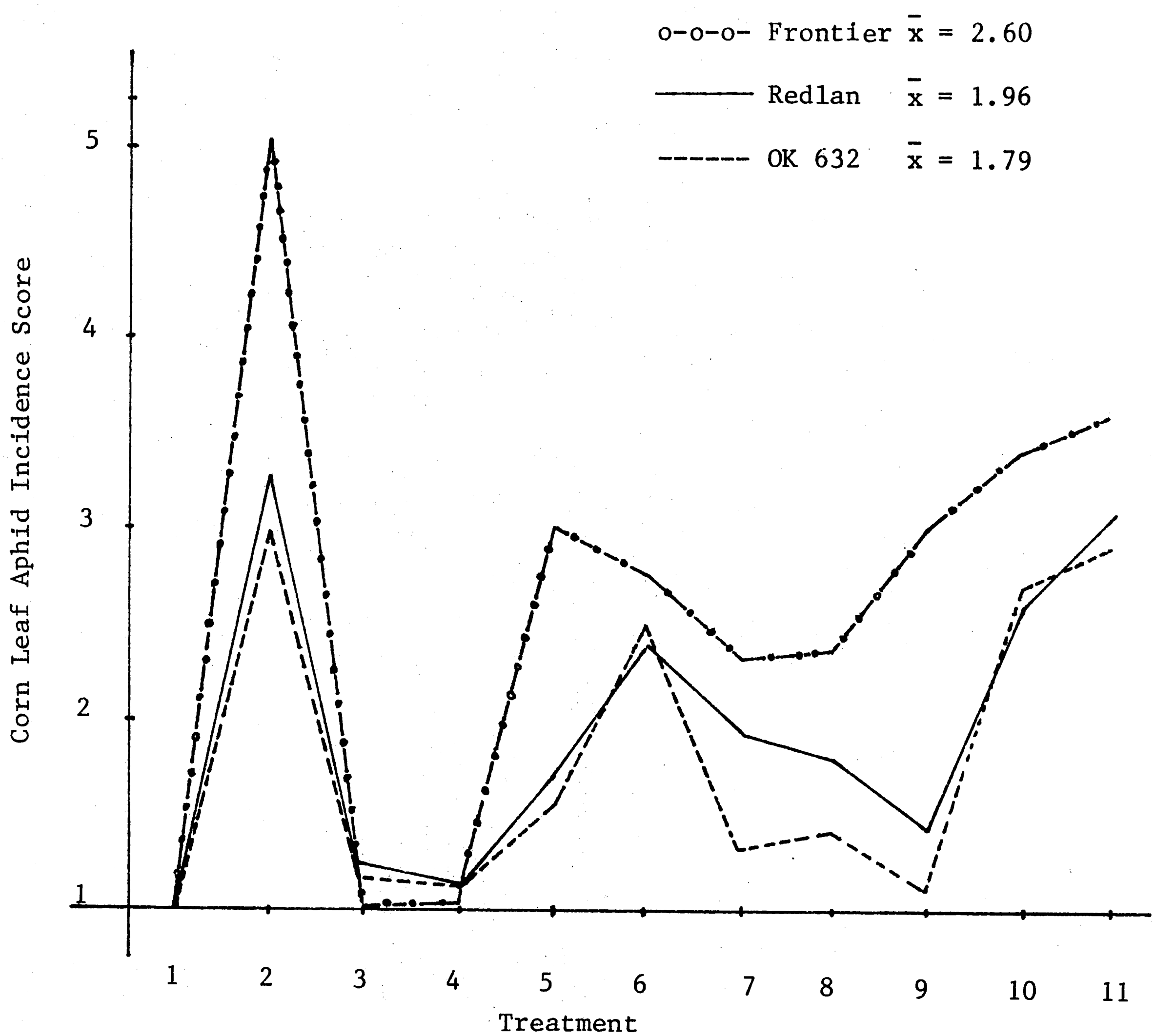

Figure 2. Relationship Among the Means of Corn Leaf Aphid Incidence Scores in Three Sorghum Varieties

of all the treatments, with mean indices of 1.00 and 3.78, respectively. Treatments 6, 5, 8, 7 and 9 gave fair control and did not differ significantly.

Methomyl and permethrin preparations, applied directly to the panicles 10 days after flowering in hope of increasing penetration of the toxicants into the center of the panicle were no more effective than the other insecticides which were dusted or impregnated into the selfing bags.

In Table IV, it can be seen that varieties OK 632 and Redlan had significantly lower corn leaf aphid incidence than Frontier. This insect probably prefers compact sorghum panicles, like Frontier, to open panicles like OK 632 as suggested by Doggett, (1970) in his materials.

None of the dosages except treatments 3 and 4 gave complete control of corn leaf aphid. However, the panicles were not severely damaged in spite of the heavy infestation of aphids in some treatments.

Corn Earworm Damage

The means for damage scores resulting from corn earworm injury to sorghum panicles are presented in Table VI, and the analysis of variance is given in Table VII. Significance was indicated for varieties and for treatments, but not for the variety X treatment interaction. This indicated that the trend among treatments in each variety was similar and that the means of the treatments for all varieties could be evaluated.

Treatment 1 (no bags) had significantly less corn earworm

TABLE VI

MEANS FOR CORN EARWORM DAMAGE SCORES

Treatment	Variety Redlan	Variety Frontier	Variety OK 632	Mean	Duncan's Range*
2	3.53	4.20	3.10	3.61	A
5	3.13	3.07	2.30	2.83	B
7	2.97	2.77	2.73	2.82	B
6	2.90	2.60	2.93	2.81	B
11	2.60	3.47	2.20	2.76	B
8	2.47	2.93	2.10	2.50	B
4	2.83	2.53	2.07	2.48	B
3	3.13	2.30	1.87	2.43	B
10	2.97	2.23	2.03	2.41	B
9	2.93	2.17	2.00	2.37	B
1	1.00	1.12	1.00	1.04	C
Mean	2.77	2.67	2.21	2.55	
Duncan's Range*	A	A	B		

*Significance level: 5%

TABLE VII

ANALYSIS OF VARIANCE FOR CORN EARWORM DAMAGE SCORES

Source	DF	MS	F Value
TOTAL	98		
REPLICATION	2	0.754	2.84
VARIETY	2	2.924	11.00**
TREATMENT	10	3.370	12.67**
VARIETY X TREATMENT	20	0.374	1.41
ERROR	64	0.266	

**Significance level: 1%

damage than the other treatments, and treatment 2 (untreated bags) had significantly more corn earworm damage than other treatments. The remaining treatments all fell in between and none was significantly different from another. Therefore, it was impossible to conclude that any chemical treatment was superior. OK 632 had significantly less corn earworm damage than the other varieties, probably because it had a more open panicle. Figures 3 and 4 present graphically the data for corn earworm damage.

Panicle Weight

Panicle weight data should have a direct relationship to the degree of injury caused by corn earworm as well as the percentage of sterility (phytotoxicity).

The analysis of variance for panicle weight may be found in Table VIII. A highly significant difference among varieties was indicated, but treatments and the variety x treatment interaction were nonsignificant. This indicated that the panicle weights for the individual treatments for each variety followed a similar trend, but statistically there were no differences among them. Duncan's Multiple Range Test (Table IX) applied to the treatment means, however, indicated that treatment 1 was different from all other treatments, except 3. Panicle weights for treatment 2 (untreated bags) were less than for all other treatments, although the difference was nonsignificant. This low panicle weight could be the result of considerable sterility (Table XVI). Redlan produced a panicle weight that was significantly less than the other varieties. This is probably related to the yield potential of this variety compared

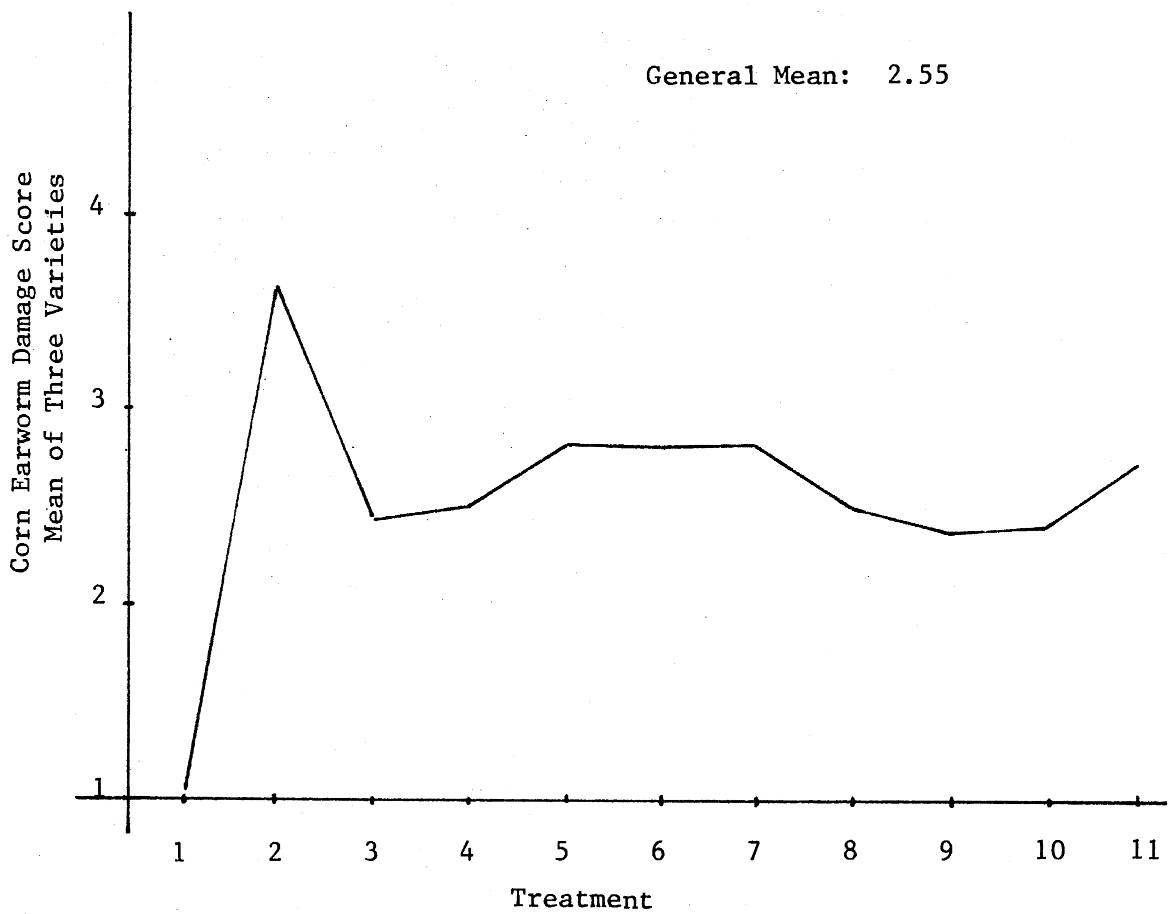

Figure 3. Distribution of the Means for Corn Earworm Damage Scores

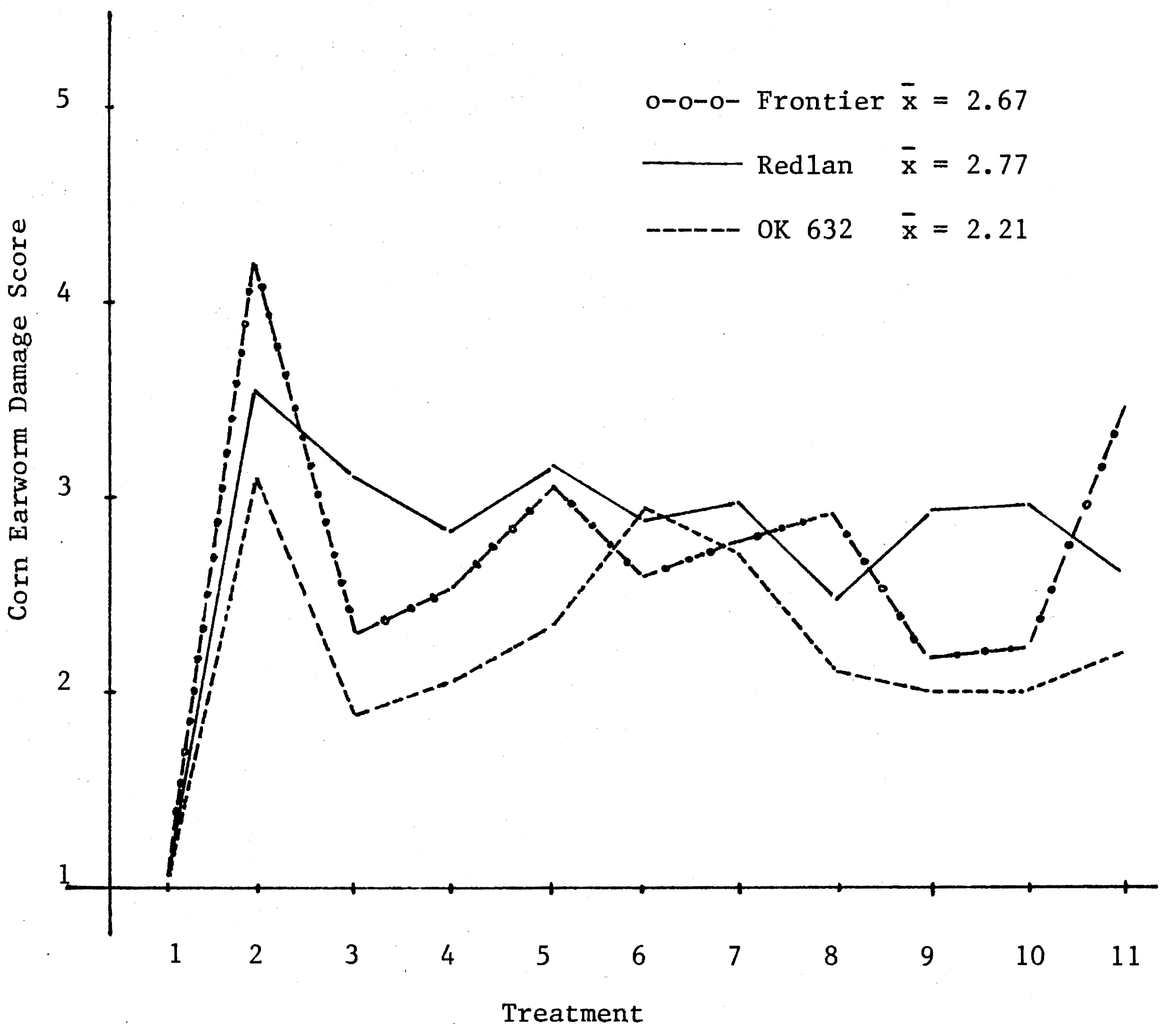

Figure 4. Relationship Among the Means of Corn Earworm Damage Scores in Three Sorghum Varieties

TABLE VIII

ANALYSIS OF VARIANCE FOR PANICLE WEIGHT

Source	DF	MS	F Value
TOTAL	98		
REPLICATIONS	2	84.470	0.52
VARIETY	2	3421.585	20.89**
TREATMENT	10	261.191	1.59
VARIETY X TREATMENT	20	216.106	1.32
ERROR	64	163.793	

**Significance level: 1%

TABLE IX

MEANS FOR PANICLE WEIGHT

Treatment	OK 632	Variety Frontier	Redlan	Mean	Duncan's Range*
	-------------------	g	--------------------		
1	112.3	140.6	96.0	116.3	A
3	102.6	112.9	98.6	104.7	AB
7	119.6	102.6	88.6	103.6	B
6	119.1	105.8	85.2	103.4	B
11	111.6	106.9	90.5	103.0	B
9	106.9	111.7	87.6	102.0	B
5	108.0	102.9	94.6	101.8	B
8	109.1	103.5	92.5	101.7	B
4	111.9	95.8	97.1	101.6	B
10	105.1	99.6	90.0	98.2	B
2	110.0	87.7	83.2	93.9	B
Mean	110.6	106.4	91.3	102.75	
Duncan's Range*	A	A	B		

*Significance level: 5%

to the hybrids.

The mean panicle weight for treatments 1 and 2 were high and low, respectively, and this agreed with damage indices calculated for corn leaf aphid and corn earworm damage (See Tables IV and VI).

In general, the average yield from unprotected panicles (Treatment 2) appeared to be slightly lower than the yield for protected panicles. However, this difference was nonsignificant. Graphic description of these data are given in Figure 5 and Figure 6.

Grain Weight per Panicle

In Table X and Figure 7 may be found the means and distribution of the treatments for grain weight per panicle. The analysis of variance in Table XI indicated that there were highly significant differences among treatments and varieties and a nonsignificant interaction. The Duncan's Multiple Range Test of treatment means revealed that few significant differences could be detected (Table X).

Treatment 1 (no bags) gave the highest grain weight per panicle, and treatment 2 (untreated bags) gave the lowest yield, but statistically they were not different from some other treatments. In general grain weight data for the treatments were similar to panicle weight data. This can be observed by comparing Figures 6 and 8.

Means for grain weight data for the varieties (Table X), however, were significantly different from each other. OK 632 gave significantly higher grain weight than the others. These differences were probably due largely to genotypic yield potential rather than to insect damage or sterility.

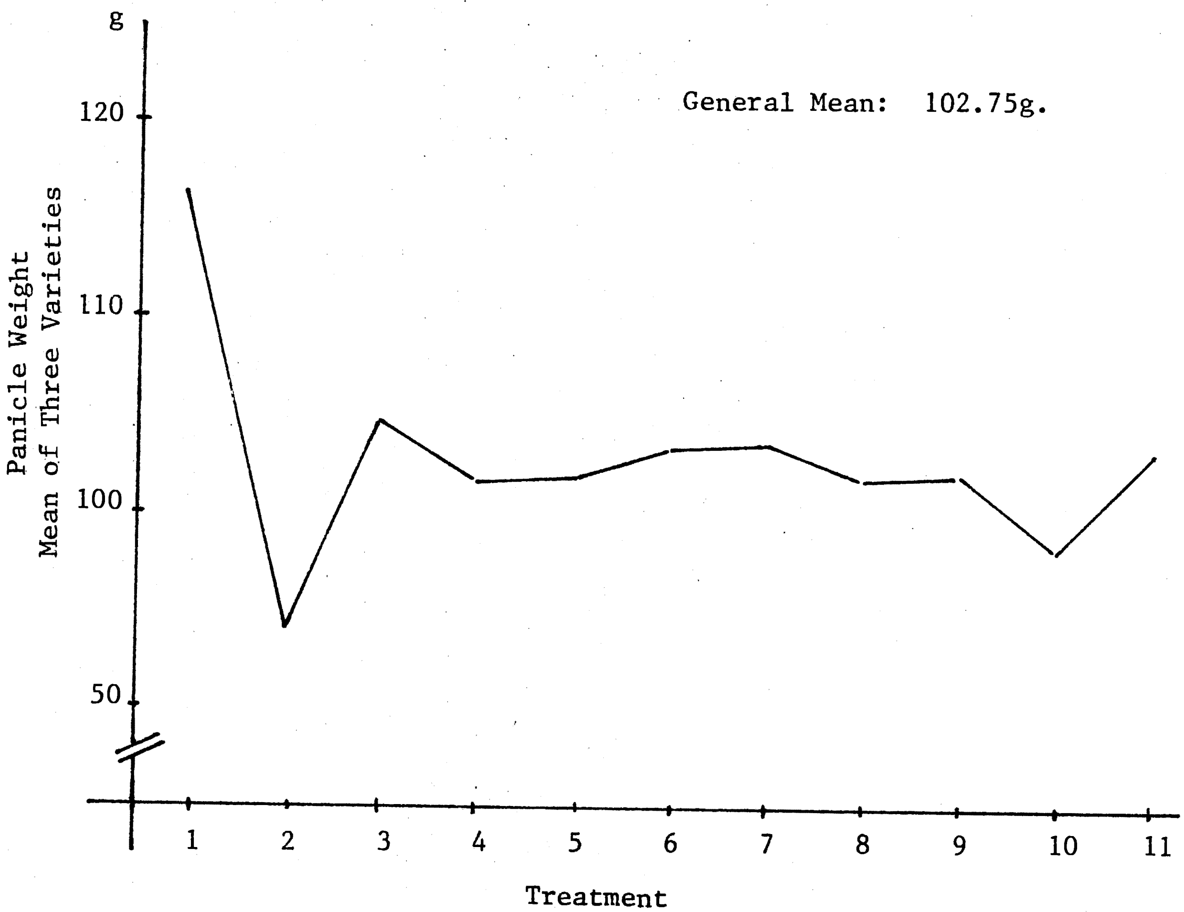

Figure 5. Distribution of the Means for Panicle Weight

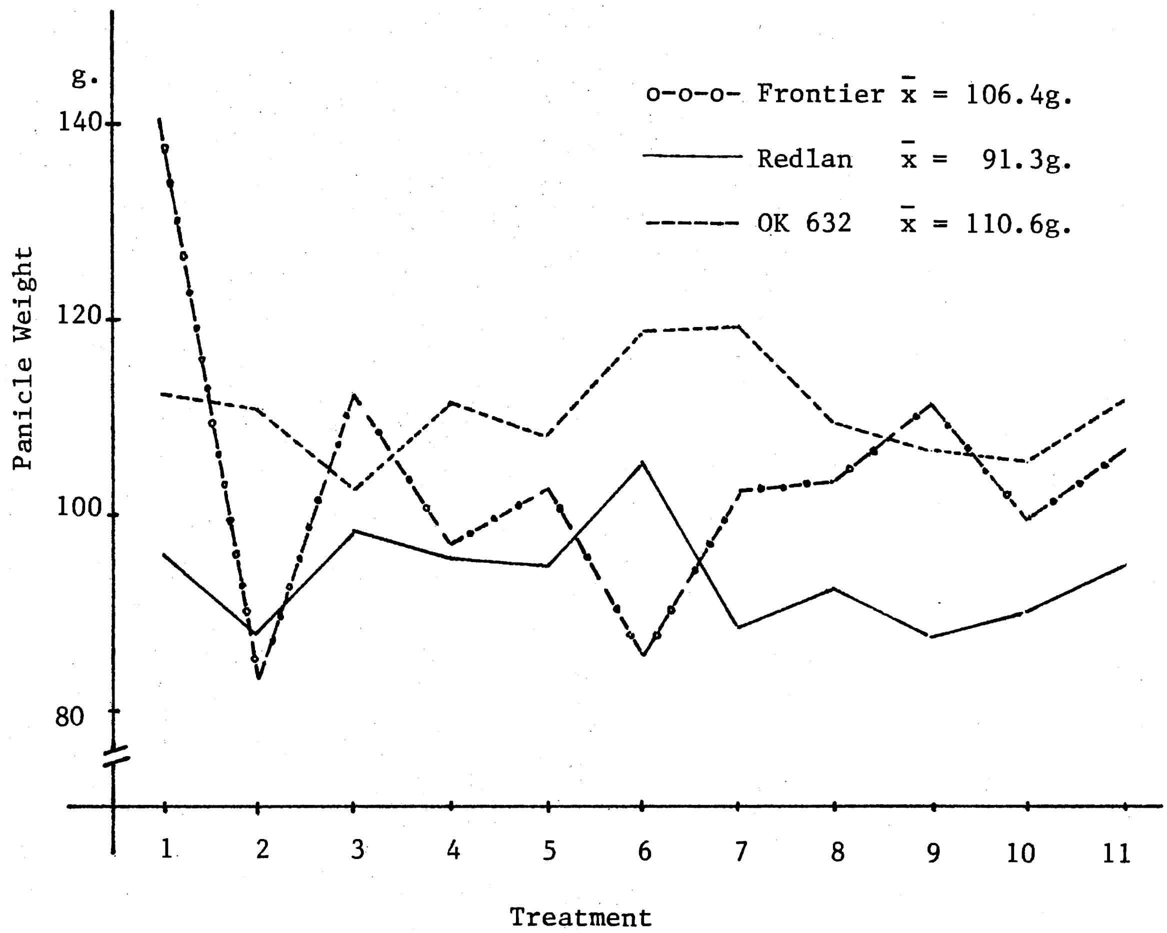

Figure 6. Relationship Among the Means of Panicle Weight in Three Sorghum Varieties

TABLE X

MEANS FOR GRAIN WEIGHT PER PANICLE

Treatment	Variety: OK 632	Variety: Frontier	Variety: Redlan	Mean	Duncan's Range*
	-------------------	g	-------------------		
1	84.3	98.3	72.5	85.0	A
3	78.3	80.6	70.5	77.8	AB
4	87.2	68.9	74.2	76.8	AB
5	82.1	74.5	71.1	75.9	AB
6	88.7	72.7	63.9	75.1	AB
11	83.3	75.2	66.4	75.0	AB
7	89.0	70.8	64.0	74.6	AB
9	79.2	77.0	66.4	74.2	B
8	78.6	69.1	67.6	77.8	BC
10	73.4	66.1	64.4	68.0	BC
2	78.5	53.5	56.9	63.0	C
Mean	82.1	73.3	67.5	74.28	
Duncan's Range*	A	B	C		

*Significance level: 5%

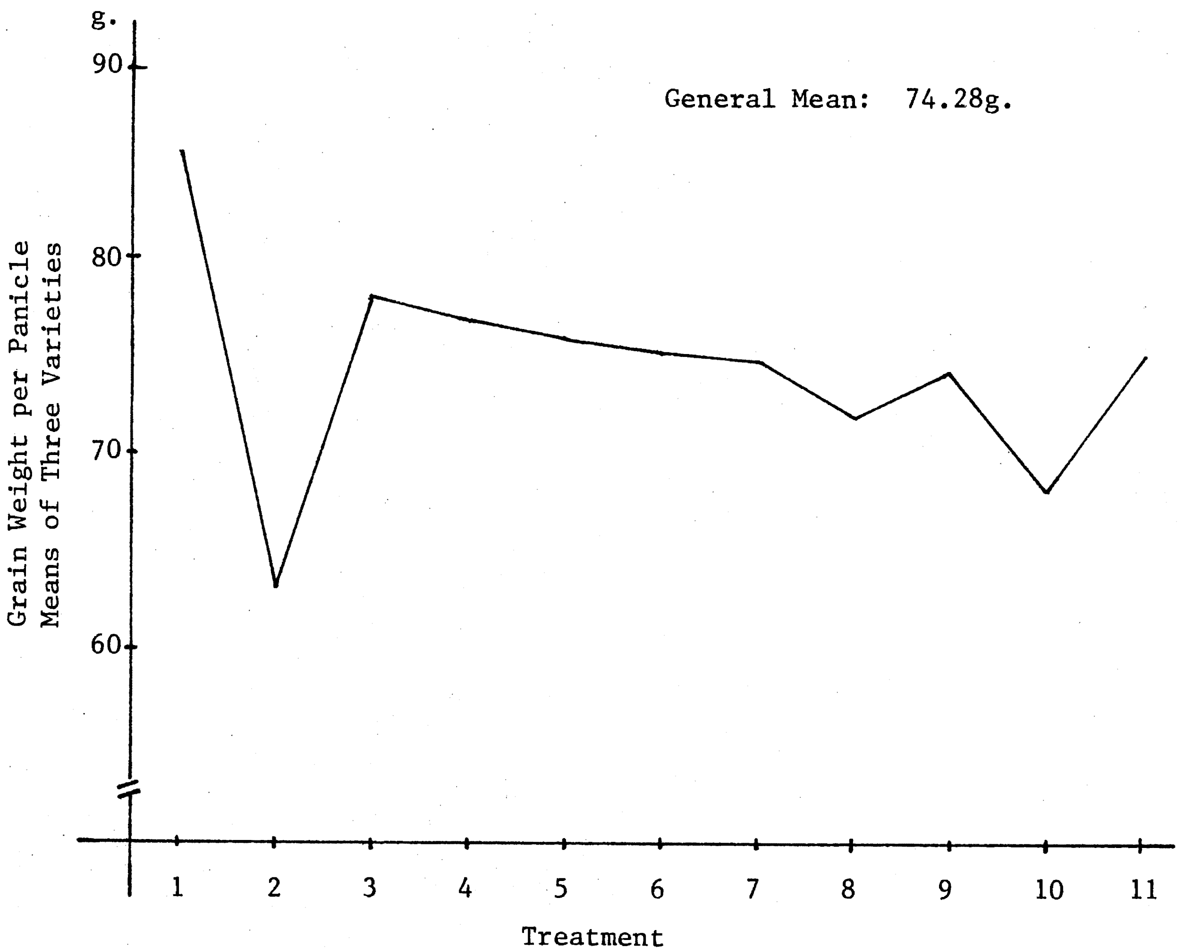

Figure 7. Distribution of the Means for Grain Weight per Panicle

TABLE XI

ANALYSIS OF VARIANCE FOR GRAIN WEIGHT
PER PANICLE

Source	DF	MS	F Value
TOTAL	98		
REPLICATION	2	102.525	1.08
VARIETY	2	1783.865	18.84**
TREATMENT	10	280.447	2.96**
VARIETY X TREATMENT	20	116.541	1.23
ERROR	64	94.662	

**Significance level: 1%

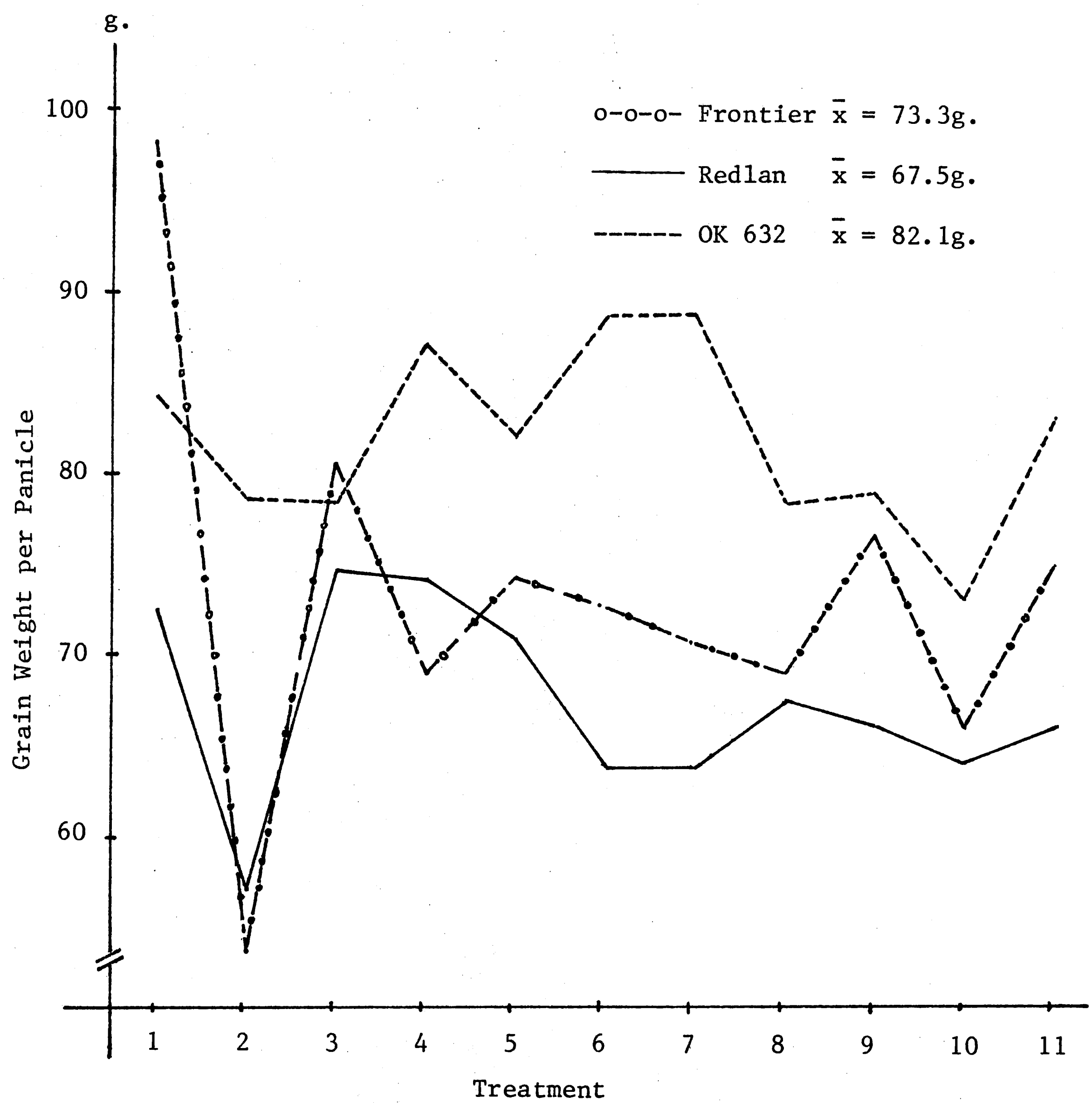

Figure 8. Relationship Among the Means of Grain Weight per Panicle in Three Sorghum Varieties

Threshing Percentage

The means for threshing percentage for the treatments in Table XII are presented graphically in Figures 9 and 10. The analysis of variance in Table XIII indicates significant differences among varieties and treatments, but the variety x treatment interaction was non-significant. Therefore the treatment means may be evaluated.

Treatments 4, 5, and 3 (Table XII) gave the highest threshing percentages but they were not different from treatment 1 (no bags). Treatment 2 (untreated bags) had the lowest threshing percentage and it was significantly different from all other treatments. Actually the range in threshing percentages for all treatments was not large (66.3 to 75.2). Apparently heavy corn earworm damage observed (Table VI) was responsible for the lower threshing percentage in treatment 2.

Varieties OK 632 and Redlan had threshing percentages significantly higher than Frontier (Table XII), partially because Frontier had more corn earworm damage than OK 632.

Weight of 100 Kernels

The means for weight of 100 kernels are presented in Table XIV. Treatments 10 and 2 gave significantly higher mean weights of kernels than the other treatments with a mean of 3.1 g. Treatments 7, 6, 11, 8, 5, and 3 gave results near the general average and did not differ significantly from each other. Treatment 9 averaged lower than all other treatments, but not significantly.

These results indicated that some of the treatments that

TABLE XII

MEANS FOR THRESHING PERCENTAGE

Treatment	Variety OK 632	Redlan	Frontier	Mean	Duncan's Range*
	%				
4	77.9	75.9	71.9	75.2	A
5	76.2	75.2	72.5	74.6	A
3	76.0	75.6	71.0	74.2	AB
1	74.8	75.4	71.3	73.9	ABC
11	74.7	73.3	70.4	72.8	BC
9	74.0	75.9	68.3	72.7	BC
6	74.3	75.0	68.3	72.5	BCD
7	74.3	72.3	69.9	71.8	CD
8	72.0	73.0	66.1	70.4	DE
10	69.7	71.4	66.3	69.1	E
2	70.8	68.0	60.3	66.3	F
Mean	74.1	73.7	68.6	72.2	
Duncan's Range*	A	A	B		

*Significance level: 5%

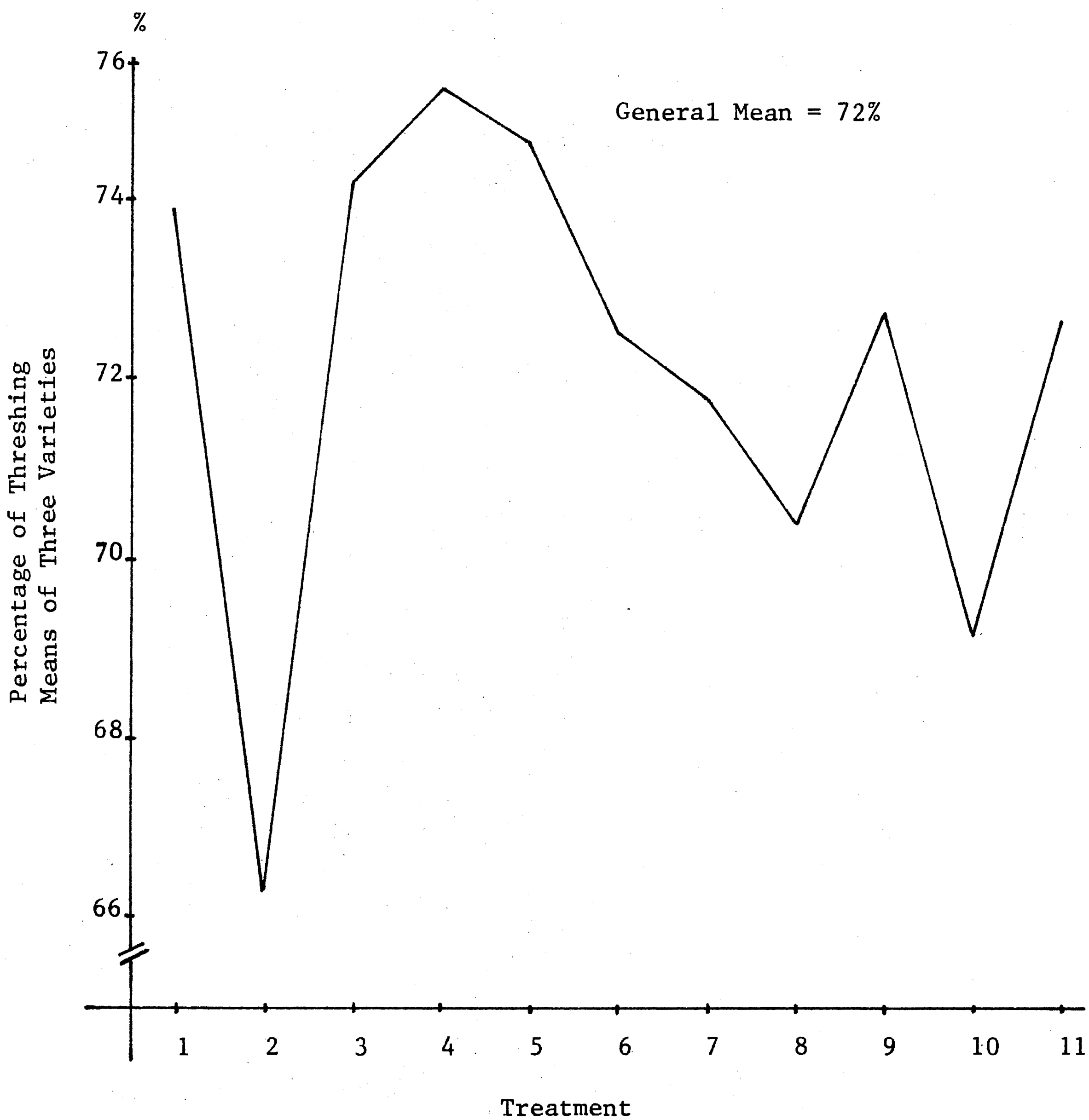

Figure 9. Distribution of the Means for Threshing Percentage

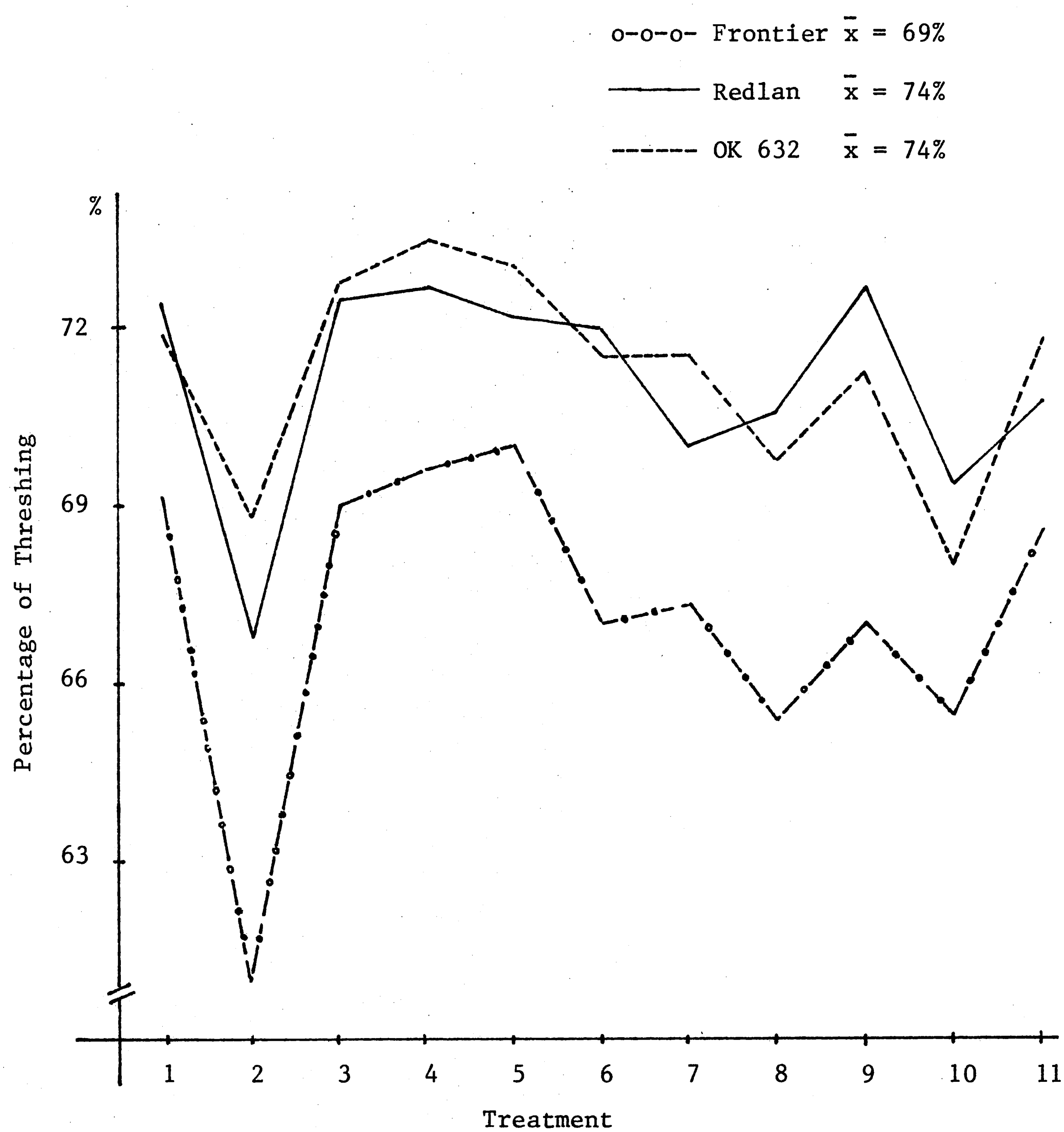

Figure 10. Relationship Among the Means of Threshing Percentage in Three Sorghum Varieties

TABLE XIII

ANALYSIS OF VARIANCE FOR THRESHING PERCENTAGE

Source	DF	MS	F Value
TOTAL	98		
REPLICATION	2	5.545	1.17
VARIETY	2	302.980	63.73**
TREATMENT	10	63.086	13.27**
VARIETY X TREATMENT	20	4.968	1.05
ERROR	64	4.754	

**Significance level: 1%

TABLE XIV

MEANS FOR WEIGHT OF 100 KERNELS

Treatment	Variety Frontier	Variety Redlan	Variety OK 632	Mean	Duncan's Range*
	---------- g ----------				
10	3.24	3.21	2.88	3.11	A
2	3.55	2.97	2.78	3.10	A
7	3.00	2.82	2.82	2.88	B
6	3.23	2.70	2.67	2.87	B
1	2.97	2.81	2.78	2.85	BC
11	3.13	2.74	2.56	2.81	BCD
8	2.84	2.87	2.62	2.78	BCD
5	2.67	2.93	2.55	2.72	BCD
3	2.76	2.91	2.40	2.69	BCD
4	2.72	2.64	2.48	2.61	CD
9	2.65	2.70	2.36	2.57	D
Mean	2.98	2.84	2.63	2.82	
Duncan's Range*	A	B	C		

* Significance level: 5%

suffered higher insect damage (treatments 2, 6, and 7, Table VI) gave highest weight of 100 kernels. This relationship agrees with the concept that when few kernels are formed in a panicle, the development of those few will be significantly better. Fisher and Wilson (1975) studied the factors that affect kernel weight by excising half of the spikelets at anthesis. The result was an increase from about 2 to over 3 g per 100 kernels.

The variety Frontier (Table XIV) had significantly larger kernels than Redlan, which in turn had significantly larger kernels than OK 632. This could be related to corn earworm damage since Frontier suffered more damage than OK 632.

The analysis of variance, Table XV, gave significant differences among varieties and treatments with no interactions. This indicated that the treatments had similar effects through the three varieties. A graphic presentation of the results is given in Figures 11 and 12.

Percentage of Sterility

The means for percentage of sterility are given in Table XVI, and the analysis of variance for these means is given in Table XVII. Means for varieties and treatments were significantly different, but since the interaction was nonsignificant, only treatment means will be discussed. Treatment 1 (no bags) gave the least percentage of sterility. In this study treatment 1 has had the least insect damage, the highest panicle and grain weight, and the least sterility of any treatment. Treatment 1 was not, however, significantly different from treatments 3, 5, and 7. The treatments with the highest level of steriltiy were treatments 8, 9, 10, and 11 but only

TABLE XV

ANALYSIS OF VARIANCE FOR WEIGHT
OF 100 KERNELS

Source	DF	MS	F Value
TOTAL	98		
REPLICATION	2	22.095	4.25
VARIETY	2	103.645	19.93**
TREATMENT	10	27.413	5.27**
VARIETY X TREATMENT	20	6.983	1.34
ERROR	64	5.201	

**Significance level: 1%

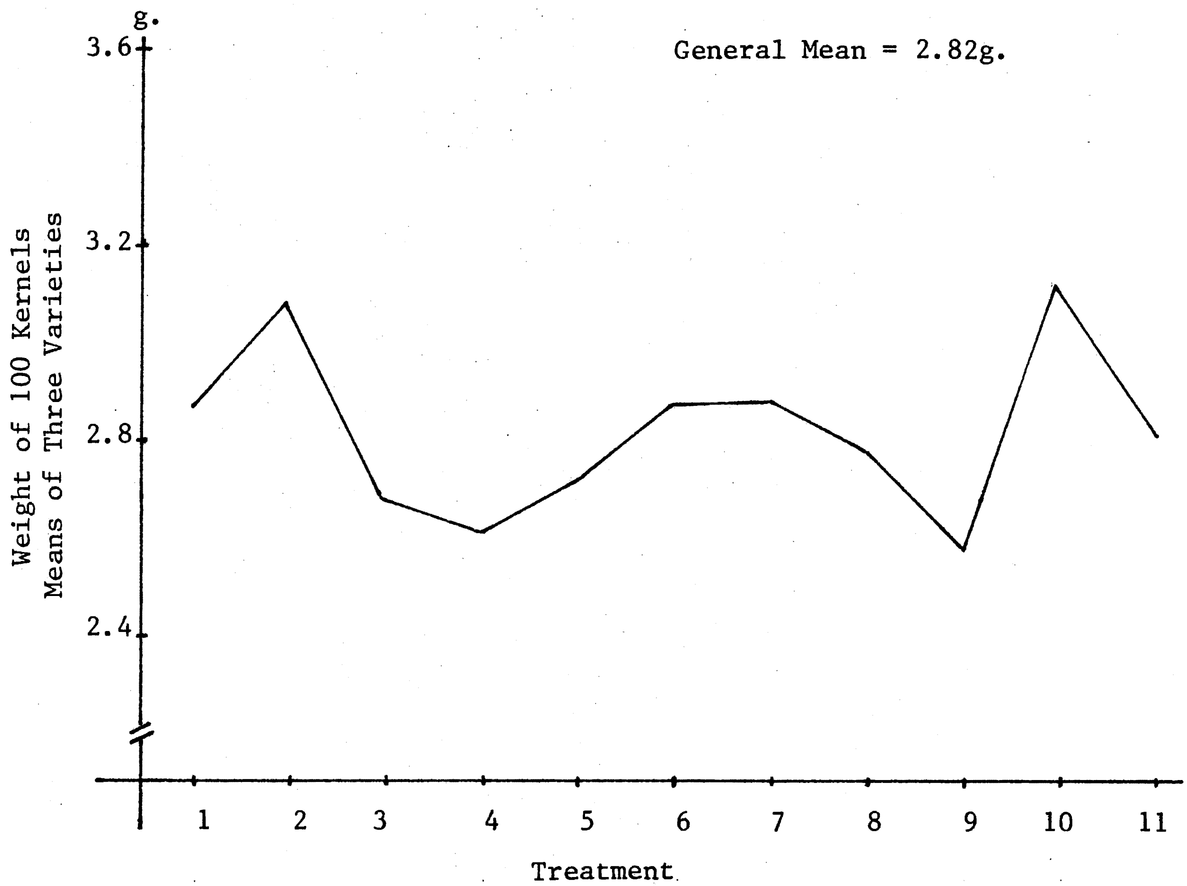

Figure 11. Distribution of the Means for Weight of 100 Kernels

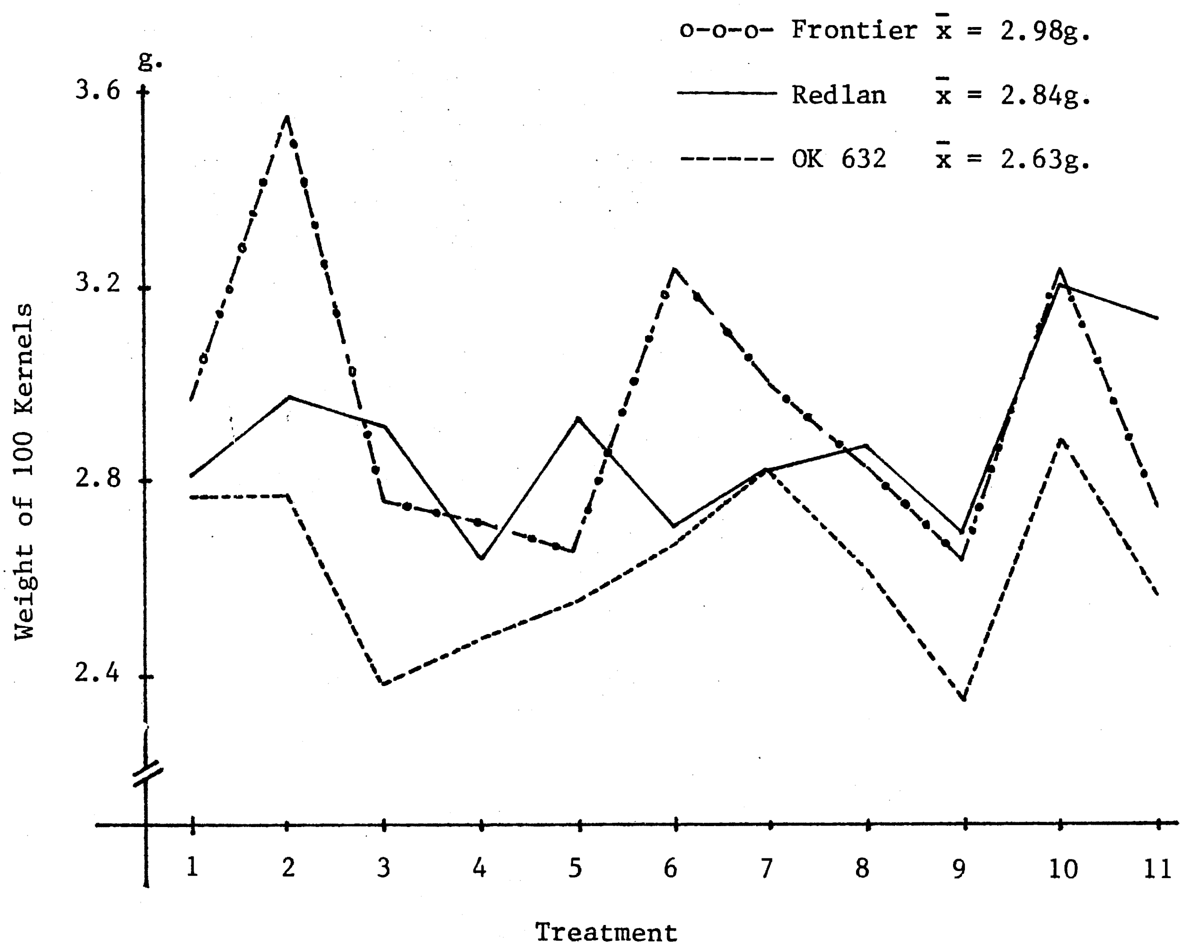

Figure 12. Relationship Among the Means of Weight of 100 Kernels in Three Sorghum Varieties

TABLE XVI

MEANS FOR PERCENTAGE OF STERILITY

Treatment	Variety Frontier	Redlan	OK 632	Mean	Duncan's Range*
	%				
11	23	11	11	15	A
10	17	14	10	14	AB
8	24	6	6	12	ABC
9	15	9	10	11	ABCD
2	16	7	7	10	BCD
4	15	7	8	10	BCD
6	16	7	7	10	BCD
7	10	7	7	8	CDE
5	13	5	5	7	DE
3	7	6	7	7	DE
1	5	5	4	5	E
Mean	15	8	7	9.9	
Duncan's Range*	A	B	B		

*Significance level: 5%

TABLE XVII

ANALYSIS OF VARIANCE FOR PERCENTAGE OF STERILITY

Source	DF	MS	F Value
TOTAL	98		
REPLICATION	2	40.990	2.21
VARIETY	2	541.345	29.13**
TREATMENT	10	80.377	4.32**
VARIETY X TREATMENT	20	28.924	1.56
ERROR	64	18.585	

**Significance level: 1%

treatments 10 and 11 were significantly different from treatments 3, 5, and 7 at the other extreme. The remaining treatments were intermediate for percentage of sterility and they were significantly different only from the very extremes. Treatment 2 (untreated bags) was one of those intermediate treatments with a fairly high level of sterility, but it was significantly different only from the extreme treatments 1 and 11.

If the level of sterility of treatment 2 (10%) is an accurate measurement of the amount of sterility produced by an untreated bag, then only those treatments with sterility greater than 10% suffered any phytotoxic effect from the insecticide. Only Permethrin (treatments 8 and 9) and Methomyl (treatments 10 and 11) appeared to produced more sterility than the untreated bags (treatment 2). Within this group of treatments, however, only 11 produced significantly more sterility than treatment 2.

From the means for the varieties it was evident that Frontier (15%) had significantly more sterility than Redlan (8%) and OK 632 (7%). Graphic views of these data are given in Figure 13 and Figure 14. The higher level of sterility in Frontier can be readily seen in Figure 14.

Percentage of Germination

The results of this study gave nonsignificant differences for this variable for all the treatments (Table XVIII and XIX). Treatment 1 (no bags) gave the highest percentage of germination with a mean of 97.7% and treatment 8 gave the lowest percentage with a mean of 94.3%, but since these were not significantly different

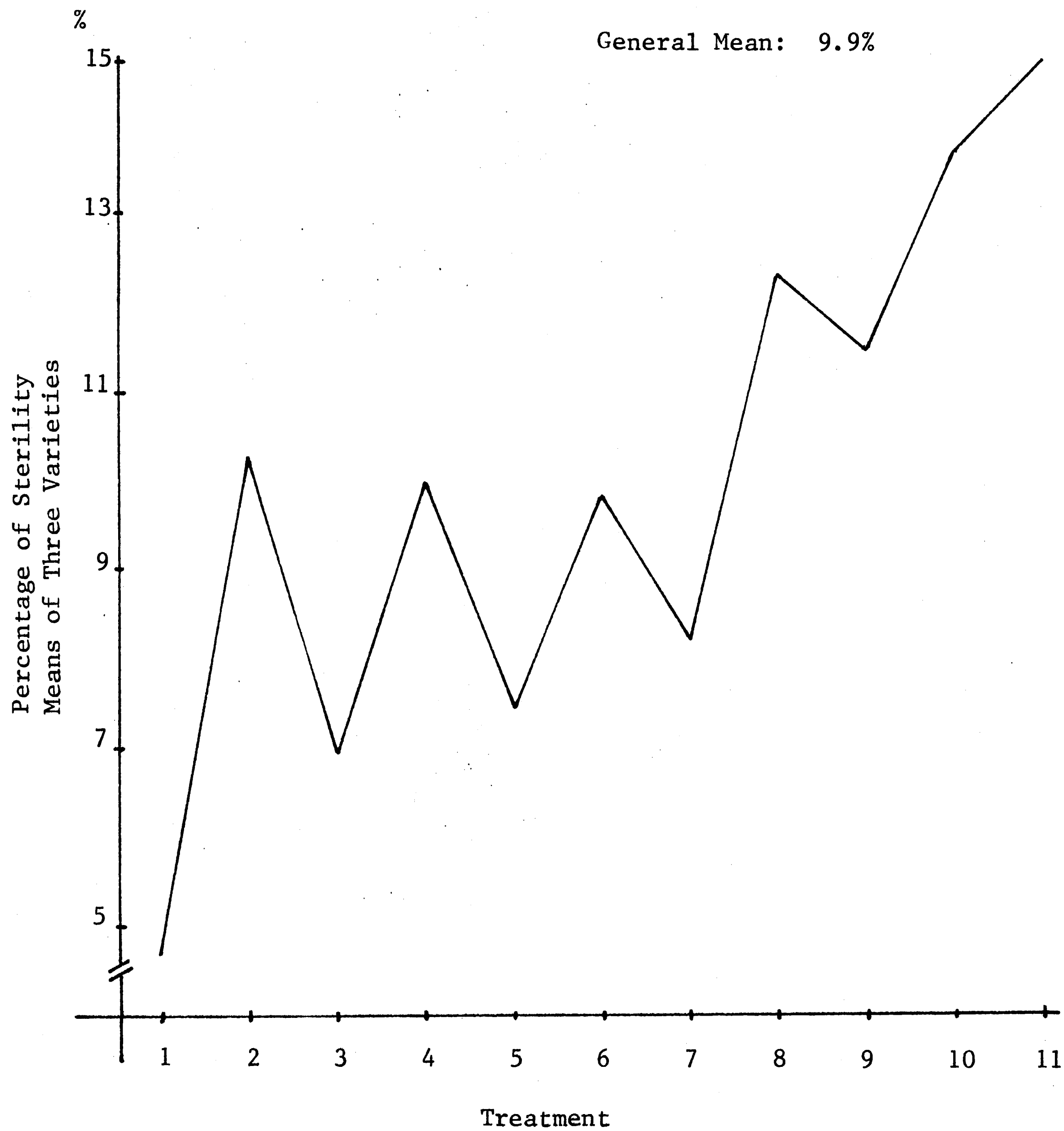

Figure 13. Distribution of the Means for Percentage of Sterility

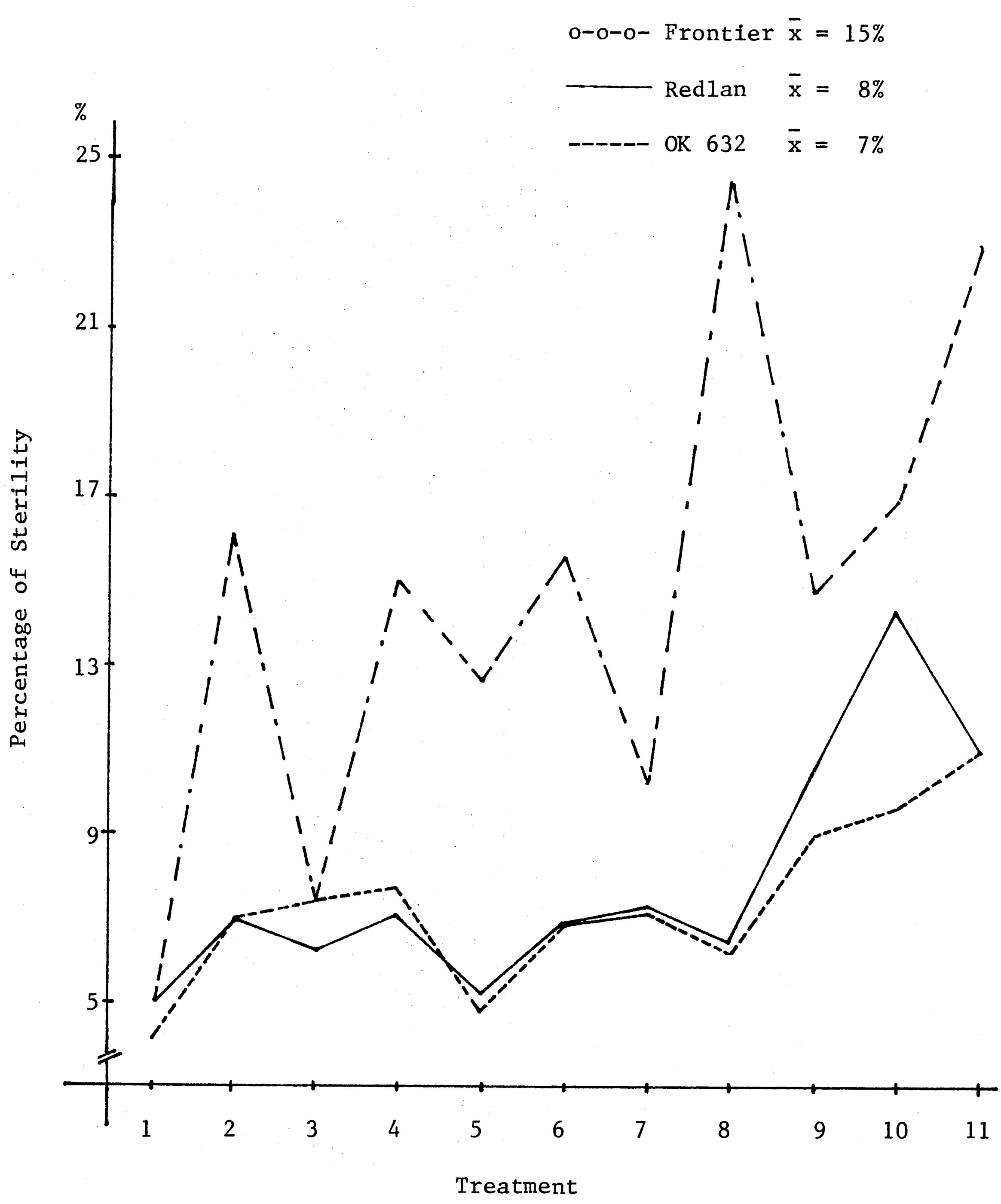

Figure 14. Relationship Among the Means of Percentage of Sterility in Three Sorghum Varieties

TABLE XVIII

MEANS FOR PERCENTAGE OF GERMINATION

Treatment	Variety: Redlan	Variety: OK 632	Variety: Frontier	Mean	Duncan's Range*
	-------------------	%	-------------------		
1	98.5	99.3	95.3	97.7	A
9	96.5	99.5	94.7	96.9	A
11	98.0	98.2	94.3	96.8	A
2	98.5	96.0	95.2	96.6	A
5	99.0	97.7	92.8	96.5	A
4	97.2	96.3	94.3	95.9	A
7	95.7	94.7	97.5	95.9	A
6	96.8	96.0	94.7	95.8	A
10	97.2	96.5	92.8	95.5	A
3	98.3	93.8	90.8	94.3	A
8	95.3	94.7	92.8	94.3	A
Mean	97.4	96.6	94.1	96.0	
Duncan's Range*	A	A	B		

*Significance level: 5%

TABLE XIX

ANALYSIS OF VARIANCE FOR PERCENTAGE OF GERMINATION

Source	DF	MS	F Value
TOTAL	98		
REPLICATION	2	17.205	1.59
VARIETY	2	94.940	8.79**
TREATMENT	10	9.924	0.92
VARIETY X TREATMENT	20	7.123	0.66
ERROR	64	10.803	

**Significance level: 1%

statistically, it was not possible to determinate which treatment was the best.

The analysis of variance, Table XIX, showed significant differences among varieties, but nonsignificance for the variety x treatment interaction. The significant differences among varieties may be related to genotypic characteristics for each variety rather than treatment effect. A graphic presentation of the results discussed above are given in Figures 15 and 16.

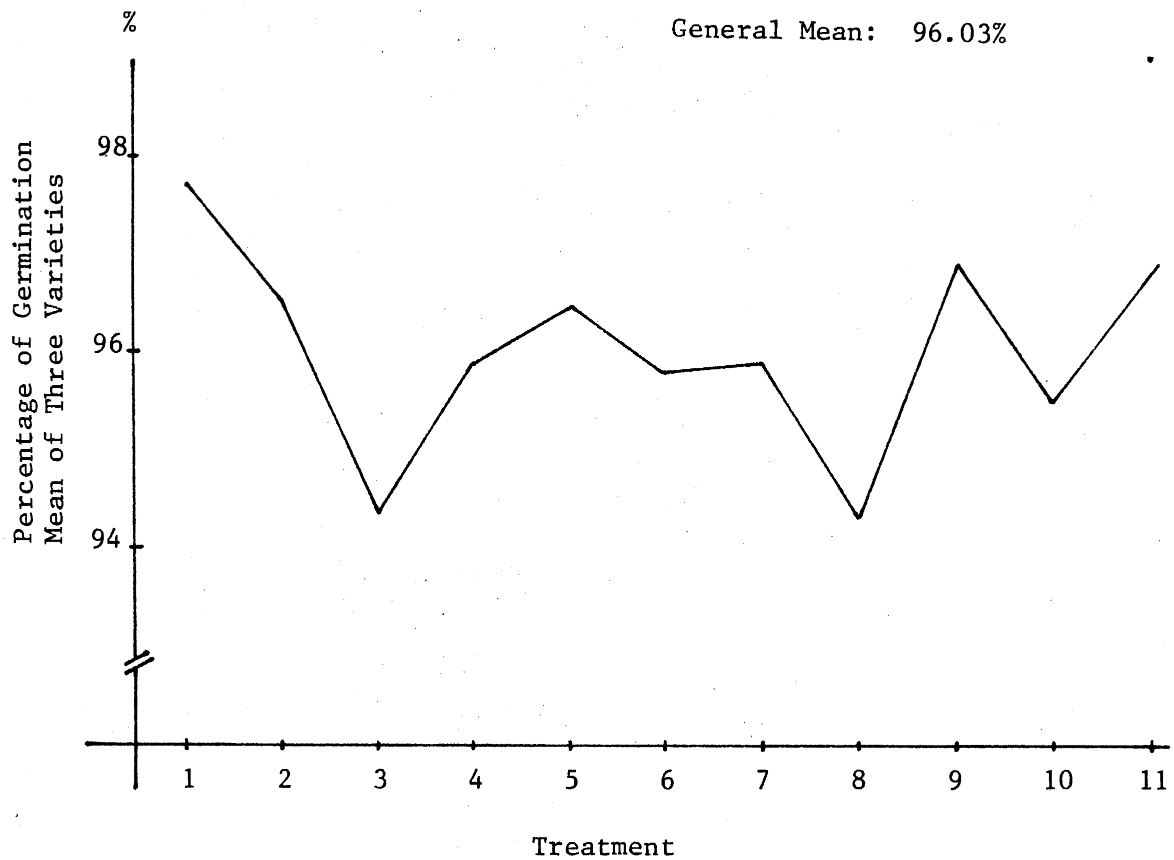

Figure 15. Distribution of the Means for Percentage of Germination

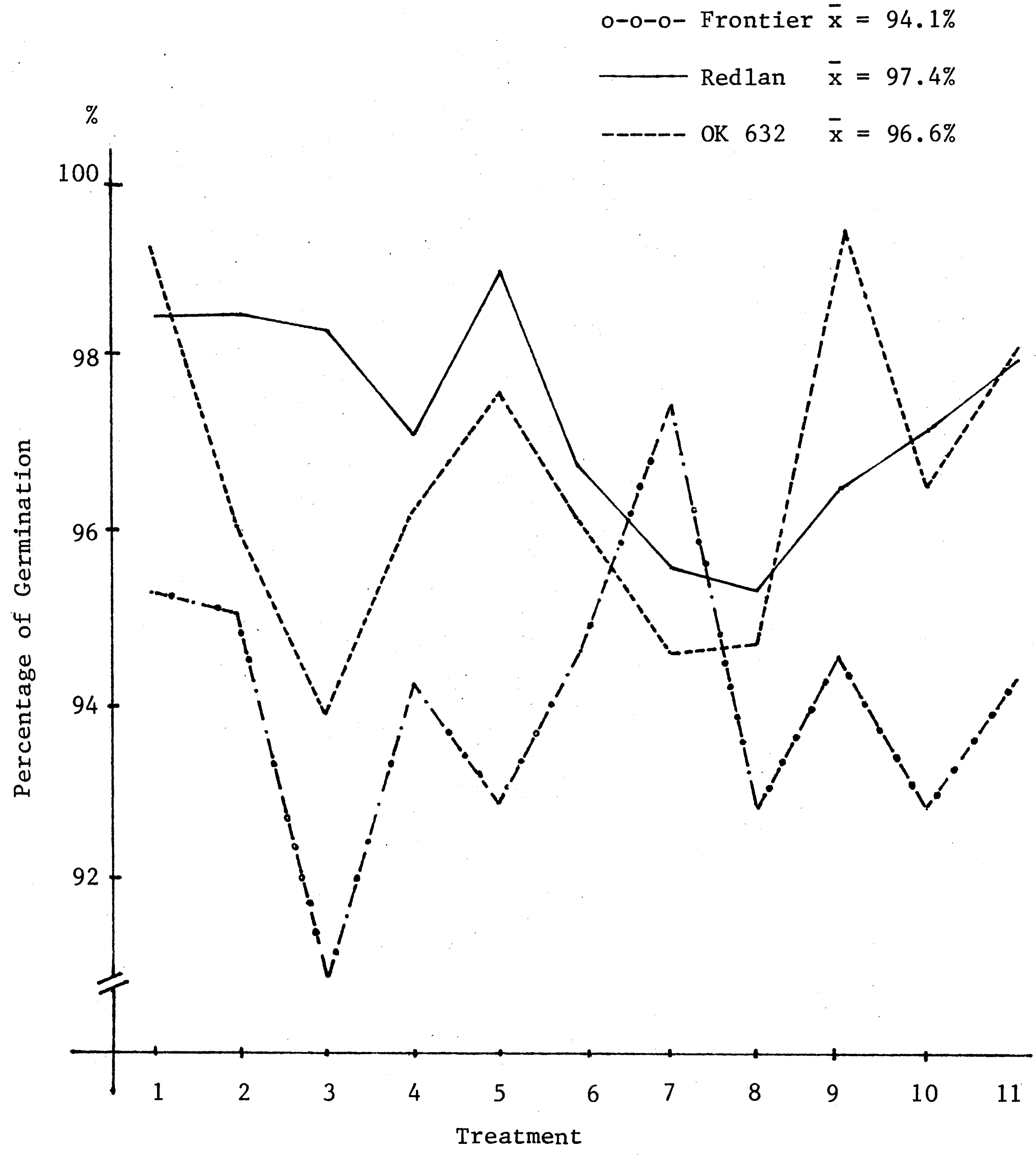

Figure 16. Relationship Among the Means of Percentage of Germination in Three Sorghum Varieties

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was designed to investigate the effect of selfing bags and insecticides on insect control and some traits in sorghum.

Eleven treatments including checks were applied to three sorghum varieties. The treatments involved the use of 6 insecticides in different combinations and dosages. The treatments were applied to the bags used to cover the panicles or directly to the panicles. This experiment was conducted at the Perkins Agronomy Research Station of the Oklahoma Agricultural Experiment Station from June to October, 1979. The experimental plots consisted of a 3 x 11 factorial arrangement in a randomized complete block design with three replications. The rows were 25 feet long and had 50 plants, approximately. Ten panicles from each treatment in each replication were selected at random prior to anthesis and covered with selfing bags. Eight variables were evaluated in this research: corn leaf aphid incidence, corn earworm damage score, panicle weight, grain weight per panicle, threshing percentage, weight of 100 kernels, percentage of sterility, and percentage of germination.

Results

1. Significant differences among varieties were found for each of the variables at the 1% level. Significance among treatments

was found for all the variables except percentage of germination. No interactions between treatment and variety were found for any of these variables.

2. Of the six insecticides tested against corn leaf aphid and corn earworm, carbaryl plus pirimicarb (treatments 3 and 4) gave significantly better control of corn leaf aphid than most of the other insecticides. Methomyl (treatment 9) gave best control of corn earworm, but it was not significantly different from the other treatments, except treatment 1 (no bags). Frontier variety showed a corn leaf aphid incidence significantly higher than Redlan and OK 632, whereas OK 632 gave a corn earworm damage significantly lower than the others. Some insects seem to prefer the more compact panicles of Frontier and Redlan.

3. All of the treatments in which insecticides were used, gave a panicle weight and grain weight per panicle relatively similar. Redlan gave a panicle weight and grain weight per panicle significantly lower than OK 632 and Frontier.

4. Treatment 4 gave a threshing percentage significantly higher than all the treatments, except 5, 3, and 1. OK 632 and Redlan varieties gave significantly better threshing percentages than Frontier.

5. Treatments 10 and 2 gave a significantly higher weight of 100 kernels than all other treatments. Methomyl (treatment 9) averaged lower than all the treatments. Frontier variety gave significantly higher weight of 100 kernels than the other varieties.

6. Treatment 11 gave a percentage of sterility significantly

higher than all the treatments except treatments 10, 8, and 9. Carbaryl plus pirimicarb (treatment 3) gave the lowest percentage of sterility, but it was significantly different only from treatments 8, 10, and 11. Frontier variety gave a percentage of sterility significantly higher than the other two varieties.

7. There were no significant differences among treatments for percentage of germination. Redlan and OK 632 varieties gave a significantly higher percentage of germination than Frontier.

8. The check (no bags) gave significantly better results than all or some other treatments in all of the variables except weight of 100 kernels, threshing percentage, and germination.

9. Treatment 2 (untreated bags) gave a significantly lower response than all or some other treatments in all of the variables except weight of 100 kernels, percentage of sterility, and germination.

Conclusions

1. None of the insecticides tested gave 100% control of corn leaf aphid but some gave a control significantly better than untreated bags. Panicles under both treated and untreated bags sustained significantly more damage than the check (no bags).

2. None of the insecticides gave a corn earworm control significantly better than the check (no bags).

3. Most of the treatments with insecticides gave yields of grain per panicle significantly higher than the untreated bags.

4. For other plant traits, treated bags gave results generally

better than the untreated bags.

5. Insecticides applied directly to the panicles gave percentages of sterility significantly higher than most of the other treatments.

6. None of the insecticides tested was harmful to germination.

7. Carbaryl plus pirimicarb gave the best corn leaf aphid control, fair but nonsignificant corn earworm control, good yield and threshing percentage, and low sterility, compared with other treatments in which insecticides were used.

Recommendations:

A. To test the toxicants that gave acceptable responses in the present experiment and other potentially useful materials at several dosages.

B. To test these toxicants mentioned in "A" on several varieties to obtain unbiased results.

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