EFFECTS OF INSECTICIDES ON CORN EARWORM, CORN LEAF APHIDS, AND SOME IMPORTANT PLANT TRAITS IN GRAIN SORGHUM UNDER SELFING-BAG CONDITIONS

By

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CHAPTER I

INTRODUCTION

Grain sorghum, Sorghum bicolor (L.) Moench, is normally self-fertilized, but some amount of crossing can occur. In order to eliminate the possibility of crossing in a sorghum breeding program, sorghum panicles are usually covered with a kraft paper bag (selfing bag) designed for this purpose.

Bagging creates a warm and humid condition which is favorable to several insect pests of grain sorghum. The corn earworm, Heliothis zea (Boddie), and the corn leaf aphid Rhopalosiphum maidis (Fitch), are two very significant pests under these conditions. Under normal conditions, they are both occasional pests in a sorghum field, but when the panicles are bagged, they can build up to levels which may cause severe damage if adequate control measures are not taken. The selfing bag serves as a protection from the many predators and parasites of these two insects, thus enhancing their build-up and damage potential.

In view of these problems various insecticides were tested in different dosages and combinations using three different varieties of grain sorghum. The purpose of this study was to determine the effects of the various insecticides on the corn earworm, corn leaf aphid, and certain important plant traits.

CHAPTER II

REVIEW OF LITERATURE

Corn Earworm

The corn earworm, *Heliothis zea* (Boddie), has many natural enemies which, under normal conditions, help to keep its populations down. Often damage done by the larvae is not great enough to be of concern. However, when selfing bags are placed on the panicles of grain sorghum, *Sorghum bicolor* (L.) Moench, the corn earworms are protected from these enemies. The bags usually remain on the panicles until harvest. Therefore, the potential for losing most, or all of the kernels to corn earworm damage is great.

Oviposition Sites

The adults of the corn earworm are seldom seen since they fly at night (La Plante, 1975). The moth lays her eggs on a wide range of host species. Corn (*Zea mays* L.) and sorghum are among the most frequently patronized crops. Lopez et al. (1978) determined that the adult preferred the upper leaf surface as a site for oviposition in the preheading sorghum, but after the start of heading almost all the eggs are layed on the panicle. They found a similar situation in corn. Most eggs were layed on the upper leaf surface before silking, but after silking started, the silk was the preferred site for oviposition.

Earlier studies (Nishida and Namompeth, 1974) had shown that the rate of egg deposition on corn was low before tasseling and increased rapidly, reaching a maximum during silking. Peak oviposition was found to occur during June on corn and sorghum in Texas (Lopez, et al., 1978). June, July, and August were recorded as the major production periods of corn earworm larvae in sorghum whorls in Oklahoma (Young and Price, 1975).

Infestation and Damage

Burkhardt and Breithaupt (1955) reported that up to 60% of the panicles were infested in sorghum fields of North-central Kansas. In these fields, 1 to 8 larvae per panicle were found. In other fields, 40 to 50% of the panicles were infested with 5 to 16 larvae. Where there were 16 larvae, 25 to 30% of the kernels were damaged or completely destroyed. Burkhardt (1955) studied insect control in grain sorghum and reported that heavy infestations by corn earworm can cause 30 to 50% grain damage. In Haskell County, Kansas, many sorghum fields were determined to be 60 to 80% infested with at least 1 to 4 larvae per panicle (Depew, 1957).

Buckley and Burkhardt (1962) reported that one larva is capable of destroying 6% of the kernels on a panicle. Where two larvae were present, they caused about 10% kernel damage. An increase of larvae in a panicle by one, gave an increase in kernel damage of 3 or 4% up to 13 larvae per panicle. They further reported that the level of damage increased with age of the larvae. Seventy-five percent total feeding was done by the last two instars.

Young and Teetes (1977) reported an economic threshold of two larvae per panicle. Starks and Burton (1979) confirmed this when they reported that, if infestation takes place at flowering time, two larvae per panicle are enough to warrant control in the absence of active and effective natural enemies.

Feeding of corn earworm larvae on sorghum results in loss in germination and loss in yields (Burkhardt, 1957). Buckley and Burkhardt (1962) determined that each increase in level of infestation gave a corresponding decrease in number of kernels damaged per larva. They further reported that undamaged kernels did not have a higher mean weight than damaged kernels, and damage of a portion of the kernels on a panicle had little effect on development of the remaining kernels.

Evaluating Damage

In most studies where corn earworm injury is measured, damage is usually rated according to the percent kernels destroyed. Dahms et al. (1955) used a method whereby they examined individual sorghum panicles and rated them on a scale of 0 to 5 with increasing numbers signifying increasing damage level. Buckley and Burkhardt (1962), working with sorghum, counted the actual number of kernels affected, and calculated the mean in order to express it as a percentage. Janes (1975) preferred to classify damage in sweet corn by corn earworm as clean or damaged.

Starks and Burton (1979) used the number of holes per bag to aid in determining infestation levels of corn earworm in grain sorghum, but there was no significant correlation between the two. They suggested, however, that since it was simple to count holes per bag, this might be useful in evaluating yield losses in experimental plots.

Corn Leaf Aphid

The corn leaf aphid, Rhopalosiphum maidis (Fitch), is another pest of grain sorghum which is greatly encouraged by covering the sorghum heads with selfing bags. Like the corn earworm, the corn leaf aphid has many natural enemies from which they are protected under these conditions.

While studying the nature of sorghum resistance to corn leaf aphid, Howitt and Painter (1956), reported that it is very difficult to obtain effective chemical control of the corn leaf aphid because of its manner of feeding down in the whorl of the plant, which protects it from insecticides. Pathak and Painter (1958) recorded the corn leaf aphid as one of the major pests of corn, sorghum, and barley. According to Mitchel (1975), it is one of the first insects to show up in the sorghum field. He listed some of the other hosts as corn, bermudagrass, asparagus, sudangrass, johnsongrass, oats, sugarcane, and wheat.

Five biotypes of corn leaf aphids have been reported (Painter and Pathak, 1962; Wilde and Feese, 1973). Biotypes have been distinguished on the basis of the effects of different hosts on the biology of the insect (Painter and Pathak, 1962) and the differences in damage produced by several biotypes on two susceptible hosts. Additional reports by Pathak and Painter (1958) supported their previous observations on distinguishing biotypes, and further showed that the number of aphids present are not as important in causing damage as is the physiology of the aphids, physiology of the host plant, and the host plant-aphid interactions.

Infestation and Damage

Hayes (1922) was among the first to report the damaging effects of the corn leaf aphid on the sorghum grain. He observed that the feeding of the insects on the panicle caused the grains to shrivel and result in poor germination. This was verified by Burkhardt (1955) when he reported that aphids feeding on the developing panicle before anthesis can prevent emergence of the panicle from the boot, encourage the production of fungi and moulds, and result in smaller, shriveled grains. Thus he got a reduction in grain weight and germinative capacity. He further reported that more compact panicles are usually more susceptible to aphid infestation.

Pathak and Painter (1958) studied the effect of feeding of the four biotypes of corn leaf aphid, then known, on susceptible sorghum and barley. They reported that significantly shorter plants were obtained in both crops with each of the biotypes. However, the results indicated that the aphids caused relatively more damage to barley than to sorghum plants and there was also some extent of root damage in both plants.

Foott and Timmins (1973) studied the effects of corn leaf aphid infestation on field corn. Their results showed that most of the injury appeared to occur before pollination was completed. Plants with very severe infestation at pollination were badly stunted. Dessication prevented the leaves in the whorl from unfolding, and ear-shoots either failed to develop or were very short. They further reported that light infestations of corn leaf aphid on field corn resulted in average yield reductions up to 8.3% under moisture stress, but losses were negligable when adequate moisture was present. Moderate infestations resulted in losses ranging from 11.8% to 34.8% under abundant moisture and drought conditions, respectively. With severe infestations, yield reductions ranged from 43.2% to 91.8% under moisture stress, and up to 58.9% even with adequate moisture. However, only small numbers of plants in a field usually reach severe levels of infestation.

More recent reports (Wilde and Ohiagu, 1976) showed that although grains from infested, treated sorghum heads were slightly heavier than grains from untreated plants, the difference was not significant. Control measures against corn leaf aphid do not increase sorghum yields when plants are infested in the whorl stage. However, corn leaf aphid can transmit maize dwarf mosaic virus which can affect yields.

Determining Infestation Levels

Most studies on corn leaf aphid damage adopt a visual system of estimating infestation levels. Dahms et al. (1955) used a rating system of 0 to 5 based on visual examination of the panicles. Zero indicated no aphids and 5 indicated that the panicle was a solid mass of aphids. Howitt and Painter (1956) reported a system in which they ranked the plants according to the degree of infestation. They assigned classes ranging from 0 to 5 which were designated: no aphids, very low, low, medium, high, and very high, respectively. Plants representing each class were selected and tagged within the plots as checks. A similar system was used by Daniels (1972) where he visually estimated infestation levels in the whorls and on the head.

In studies done with corn, aphid population on the tassel was estimated at pollination (Foott and Timmins, 1973). The following categories were established: nil to very light - 0 to 50 aphids, light - 50 to 400 aphids, moderate - many hundreds of aphids on parts of the tassel, severe - many hundreds of aphids on all of the tassel and leaf whorl.

The method used by Wilde and Ohiagu (1976) was different from those previously discussed. Sampling was done in the laboratory by brushing the aphids into 95 percent alcohol, pouring the alcohol-aphid mixture in a graduated cylinder and rotating to settle the aphids to the bottom. Several counts were made to calculate corn leaf aphids per ml.

Howitt and Painter (1956) related infestation levels of corn leaf aphid on sorghum to resistance. They reported that although much information was available on the reaction of corn inbreds and hybrids to this insect under Kansas conditions, published information regarding resistance of sorghum to corn leaf aphid is limited. In their studies, Howitt and Painter (1956) used three criteria in determining the resistance of sorghum varieties to the corn leaf aphid. These were percent infestation, winged aphids per plant per day, and number of progeny per infested plant. They tested for preference, antibiosis, and tolerance using 595 varieties of sorghum involving 13,662 plants. A wide range of infestation was found among these varieties. The Sudan types demonstrated a consistently high level of resistance through non-preference and antibiosis, while Combine Kafir, and Milo types showed high levels of susceptibility in both preference and antibiosis tests. Some differences in resistance were shown between plants of the same strain.

Control of the Corn Earworm and Corn Leaf Aphid

Both corn earworm and corn leaf aphid may occur in the same panicle concurrently, or one may increase with the decrease of the other. It is, therefore, often necessary to use combinations of insecticides to effect control.

Dahms et al. (1951) studied the use of insecticide-treated bags to protect sorghum heads. In these studies, the corn earworm was controlled by some insecticides which encouraged an increase of corn leaf aphids. Others controlled both insects, but caused a high degree of sterility. Twelve insecticides were tested in more than 50 combinations and dosages and from these, aldrin gave the most satisfactory control. Heptachlor showed some promise, but was not tested as much as aldrin.

Further studies (Dahms et al., 1955) showed that various methods could be used in treating sorghum selfing bags, but some were not effective and, in some cases, not practical. Dusting the sorghum heads, dusting the inside of the bags, impregnating the bags, streaking the inside of the bags, and spraying the sorghum heads were the five methods experimented with. Several different insecticides and combinations were used in these treatments. Impregnating seemed to be the best method since it was more practical than the others. DDT impregnated at the rate of 133 mg per bag, or above, gave excellent control of corn earworm, but caused corn leaf aphids to increase. Five-tenths percent aldrin and .05 to 1% heptachlor gave excellent corn earworm control, good aphid control, and almost no sterility when impregnated. Other insecticides which gave good control of the corn earworm were parathion, BHC, lindane, demeton, dieldrin, metacide, and TEPP. However, BHC, lindane, and parathion caused high sterility. Lindane, BHC, heptachlor and demeton also gave good aphid control. DDT-TEPP and DDT-lindane combinations gave good control of both insects without causing much sterility, while toxaphene-lindane combinations caused very high levels of sterility.

In other studies (Burkhardt, 1955) best control of the corn leaf aphid was obtained when sprays were applied to the panicle at early heading. Endrin, malathion, and lindane gave the best results in these tests. Lindane and endrin were also effective against the corn earworm. DDT gave good corn earworm control.

Reports by Burkhardt and Breithaupt (1955) can be used to verify heptachlor and DDT as effective control for corn earworm. In their studies, they also found that OS-2046, a systemic insecticide, gave 96 and 100% earworm control after 24 and 96 hours, respectively.

Depew (1957) studied corn earworm control in sorghum heads by aerial spraying in south-western Kansas. He reported that phosdrin, DDT, malathion, endrin, and parathion gave satisfactory control. His findings also confirmed findings by Burkhardt and Breithaupt (1955) that the level of control obtained depends on the period of time after which observations are made. Observations after longer periods showed higher levels of control.

Another study by Burkhardt (1957) gave further evidence that DDT and phosdrin were effective in controlling the corn earworm in grain sorghum. Endrin, heptachlor, parathion, and malathion were found to give fair control. He also reported that aerial applications gave a slower kill than ground applications.

Foott (1975) studied chemical control of the corn leaf aphid on field corn over a three-year period. He reported that every treatment which was applied gave a reduction in aphid infestation and significant increase in yield. The systemics dimethoate and oxydemeton-methyl were particularly effective.

Carbaryl, methomyl, and gardona were used to control the corn earworm in sorghum in Hawaii (La Plante, 1975). They were highly recommended because they had little or no residual effect.

Janes (1975) reported that methomyl and methomyl + chlorodimeform combination gave effective control of the corn earworm and fall armyworm in sweet corn in Florida, but further stated that it would take daily applications to obtain commercially acceptable corn with 98% worm-free ears.

Recent publications (DuRant, 1979) showed that permethrin, dawco, profenofos + chlorodimeform, fenvalamate + acephate, and EPN + methyl parathion were effective in controlling the _Heliothis_ spp., including the bollworm, in cotton.

Insecticide Phytotoxicity

Phytotoxicity problems can limit the use of some effective insecticides on a crop, however, studies by Harding (1965), DuRant (1977), and Luttrell et al. (1979), showed that phytotoxicity does not necessarily affect yield. Harding (1965) reported that disulfaton, toxaphene, methyl parathion, and trithion showed easily noticeable to extreme phytotoxic damage on grain sorghum, but did not reduce yields. Luttrell et al. (1979) showed that phytotoxicity, due to excessive amounts of methomyl in field and laboratory studies, did not appear to affect yield of cotton. DuRant (1979) reported that moderate leaf reddening was caused by methomyl on cotton, but defoliation was light. He further reported that any yield reductions due to methomyl phytotoxicity were more than offset by the yield increases effected due to enhanced _Heliothis_ spp. control afforded by methomyl.

CHAPTER III

MATERIALS AND METHODS

The experiment involved three varieties of grain sorghum, Redlan, OK632, and Frontier 412R. Plots were located on the Oklahoma State University Agronomy Research Station at Perkins, Oklahoma from June to October 1980. The soil series was Teller loam which is a member of the fine-loamy, mixed, thermic, Udic Argiustoll. Twelve treatments, including checks were involved in this experiment (Table I). Nine different insecticides were used in different dosages and combinations (Table II). These were toxaphene, pirimor, sevin, methomyl, ambush, malathion, diazinon, dipel, and lindane. Combinations were used in cases where one insecticide was recommended or expected to control only one of the insects. Sevin + pirimor, toxaphene + pirimor, ambush + malathion, ambush + diazinon, dipel + pirimor, and lindane + malathion were the combinations used (Table I). Different methods of applying these treatments were adopted. These are also shown in Table I.

The experimental design was a randomized complete block with three replications. A single row containing approximately 50 plants was used as an experimental unit. Cultural practices adopted followed the standard practices used in the Oklahoma State University sorghum breeding program.

Twelve plants were selected at random from each row before blooming occurred. Each panicle was infested with day-old corn earworm larvae at

TABLE I

TREATMENTS AND DOSAGES OF INSECTICIDES USED

Treatment	Toxicant per bag (Active Ingredient)	Method of Application
1. No bags (check)	----------------	------------
2. Untreated bags	----------------	------------
3. Toxaphene & pirimor	184 mg & 60 mg	Impregnated
4. Sevin & pirimor	20 mg & 50 mg	Dusted
5. Sevin & pirimor	20 mg & 50 mg	Impregnated
6. Methomyl	48.2 mg	Injected
7. Ambush & malathion	47.8 mg & 100 mg	Injected
8. Ambush & diazinon	47.8 ml & 60 mg	Injected
9. Diazinon	60 mg	Impregnated
10. Malathion	100 mg	Injected
11. Dipel & pirimor	160 mg & 100 mg	Dusted
12. Lindane & malathion	45 mg & 100 mg	Injected

TABLE II

INSECTICIDES USED IN THE EXPERIMENT

Common Name & Trade Name	Chemical Name	Concentration & Formulation	Oral Toxicity in Rats: LD_{50}	Oral Toxicity in Rats: Rating
Toxaphene	Octachlorocamphene	60% Emulsifiable Concentrate	90 mg/kg	High
Primicarb (Pirimor)	2-(dimethylamino)-5,b-dimethyl-4-pirymidinyl dimethylcarbamate	50% Wettable Powder	500 mg/kg	Medium
Carbaryl (Sevin)	1-Naphthyl N-methylcarbamate	50% Flowable	500 mg/kg	Medium
Methomyl (Nudrin)	5-methyl N|(methylcarbamoyl)Oxy| thioacetatimidate	24.1% Emulsifiable Concentrate	17 mg/kg	V. High
Permethrin (Ambush)	(3-phenoxyphenil)methyl(±)cis, trans-3-(2,2-dichloroethenyl)-2, 2-dimethylcyclopropane-carboxilate	23% Emulsifiable Concentrate	4000 mg/kg	V. low
Malathion (Lorox)	0,0-dimethylphosphorodithioate of diethylmercaptosuccinate	50% Emulsifiable Concentrate	1000 mg/kg	Low
Diazinon (Basudin)	0,0-diethylo-(2-isopropyl-6-methyl-4-pyrimidinyl)phosphorothioate	12.5% Emulsifiable Concentrate	108 mg/kg	High
<u>Bacillus thuringiensis</u> (Dipel)	----------------------------------	16,000 International units/mg wettable powder	non-toxic	-------
Lindane (Lime Sulphur)	1,2,3,4,5,7-hexachlorocyclohexane, gamma isomer	20% Emulsifiable Concentrate	91 mg/kg	High

the rate of about seven larvae per panicle using a hand applicator. These larvae were obtained from cultures grown on artificial diet in the laboratory. The infested panicles were bagged immediately to prevent escapes or predation. Bags were allowed to remain on the heads until harvest. Corn leaf aphid population seemed adequate throughout the field so artificial infestation was not done.

The methods of application were dusting the inside of the bags, impregnating the bags with an emulsion, and spraying directly onto the heads. Dusting was done by placing the required amount of insecticide inside the bag and shaking it around, while impregnating was done by soaking the bags in an emulsion until they were saturated. The bags were allowed to dry before using. Spraying the heads was done by injecting the insecticide through the bags after bagging.

At maturity each panicle was harvested separately without removing the bag. The number of holes made in the bags by the corn earworm were counted and recorded as an indication of the number of larvae that survived on a panicle.

Before threshing, heads were rated for sterility, corn earworm damage, and corn leaf aphid incidence. These were rated visually on a scale of 1 to 6 (Table III) which is a modification of the scale of 0 to 5 used by Dahms et al. (1955). Corn earworm damage estimates were a function of the amount of frass present on a head, while corn leaf aphid damage estimates were based on the amount of scales remaining on the panicle and the amount of honeydew produced. Sterility was based on the percentage of undeveloped spikelets. Panicle weight was recorded individually.

After threshing, grain weight per panicle was recorded. One

TABLE III

RATING SCALES USED FOR MEASURING STERILITY AND INSECT DAMAGE

Scale	Sterility	Corn Leaf Aphid	Corn Earworm
1	None	None, no exuviae	None, no frass
2	5% or less on tip	1-10 aphids, some exuviae	1 larva or small amount of frass, less than 5% kernel damage.
3	6-20%	10-50 aphids, some exuviae	1 larva, moderate amount of frass, 6-20% kernel damage
4	21-40%	50-200 aphids, some exuviae, some honeydew	2 larvae, large amount of frass, 21-40% kernel damage.
5	41-80%	Aphids or exuviae throughout panicle, much honeydew	More than 2 larvae, large amount of frass, 41-80% kernel damage.
6	Above 80%	Panicle a solid mass of aphids, exuviae and honeydew	More than 2 larvae, large amount of frass, more than 80% kernel damage.

hundred seeds were counted out from each panicle and the weights recorded. Two out of each 10 samples of 100 seeds were selected at random and tested for germination. This was used in determining the effect of insects and chemical treatments applied for their control on the germinating capacity of the seeds. To eliminate the possibility of fungus infection, the seeds were treated with a fungicide (Vitavax 200) before being placed in the germinating chamber. A daytime temperature of 30°C and night-time temperature of 20°C was maintained in the chamber. Humidity was high, but uncontrolled. Germination counts were made after seven days.

Threshing percentage was determined using the values from panicle weight and grain weight per panicle. Of the 12 panicles bagged, only 10 were used in presenting the data in this study. Statistical analysis was done using Duncan's Multiple Range test of the means. F values from the analysis of variance were used in determining and comparing effectiveness of each treatment.

CHAPTER IV

RESULTS AND DISCUSSION

Corn Earworm Damage

The means for corn earworm damage are shown in Table IV and the analysis of variance in Table V. The analysis of variance indicated significant differences among varieties and among treatments. The variety X treatment interaction was not significant. The variety OK632 showed significantly less corn earworm damage than Redlan and Frontier 412R (Table IV). This is conceivable because OK632 has a more open-type panicle than the others, and this is not preferred by the corn earworm. Frontier 412R had the highest mean, but it was not significantly different from Redlan. Figure 1 shows the distribution of the treatment means for corn earworm damage and a graphic comparison of the means for corn earworm damage of the three varieties may be found in Figure 2.

Panicles which received treatment 2 (untreated bags) had a significantly higher mean corn earworm damage than all other panicles (Table IV). Panicles receiving treatment 5 (Sevin + Pirimor dipped) had next to the highest damage, and had significantly more corn earworm damage than all other treatments except 2. Treatment 3 (Toxaphene + Pirimor dipped) ranked next, and it had significantly less damage than treatments 2 and 5, but more than the remaining treatments. Ambush + Diazinon injected directly onto the panicles through the selfing bag (treatment 8)

TABLE IV

MEANS FOR CORN EARWORM DAMAGE SCORES

Treatment	Variety			Mean	Duncan's Range
	Redlan	OK632	Frontier 412R		
2	3.10	2.50	3.03	2.88	A[1]
5	2.26	1.26	2.46	2.00	B
3	2.10	1.23	1.63	1.65	C
6	1.40	1.40	1.40	1.40	D
9	1.36	1.03	1.46	1.28	DE
10	1.16	1.06	1.43	1.22	DE
11	1.13	1.00	1.46	1.20	DE
7	1.10	1.10	1.23	1.14	DE
12	1.10	1.00	1.00	1.03	E
1	1.00	1.00	1.06	1.02	E
4	1.00	1.00	1.06	1.02	E
8	1.00	1.00	1.00	1.00	E
Mean	1.48	1.21	1.52		
Duncan's Range	A	B	A		

[1]Means with the same letter are not significantly different at the .05 significance level.

TABLE V

ANALYSIS OF VARIANCE FOR CORN EARWORM DAMAGE SCORES

Source	DF	MS	F Value
Total	107		
Replication	2	0.127	1.76
Variety	2	0.988	13.66**
Treatment	11	2.757	38.11**
Variety X Treatment	22	0.148	2.06
Error	70	0.072	

**Significant at the .01 level of significance.

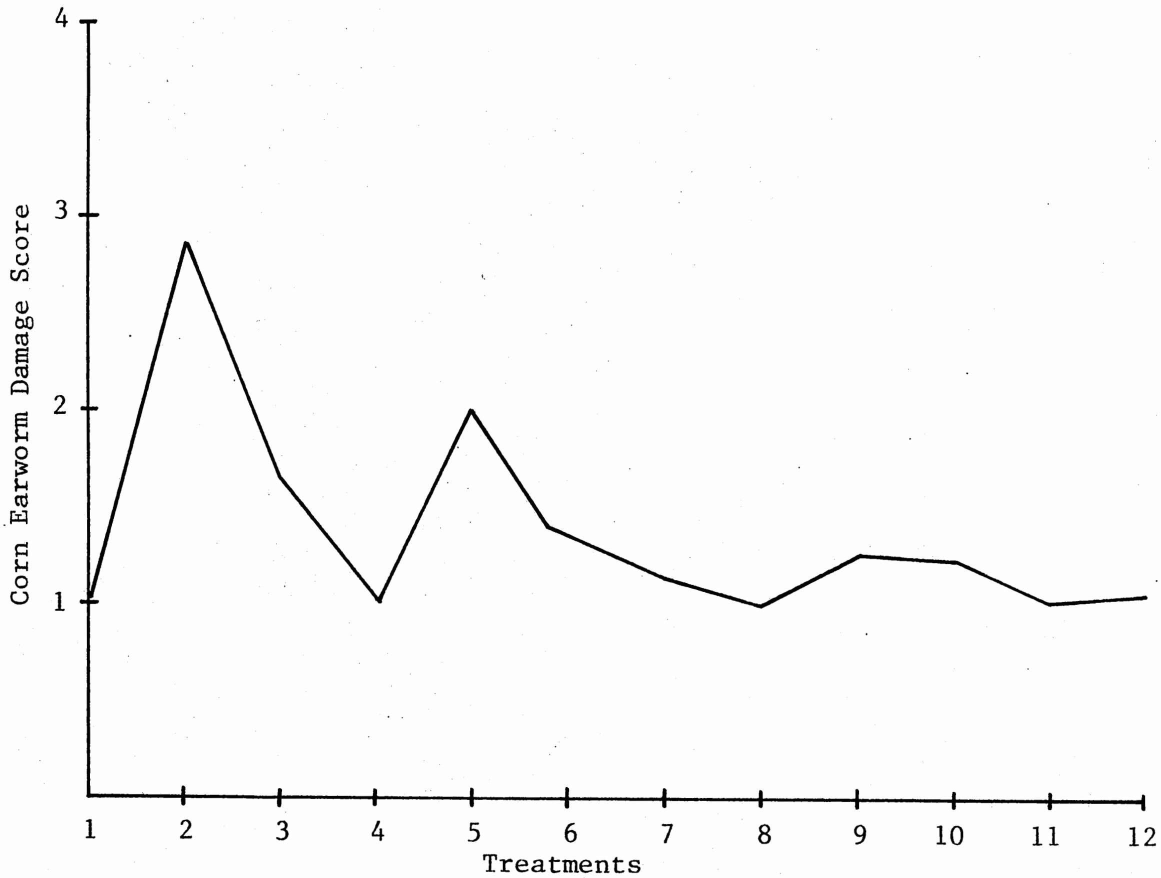

Figure 1. Distribution of Treatment Means for Corn Earworm Damage

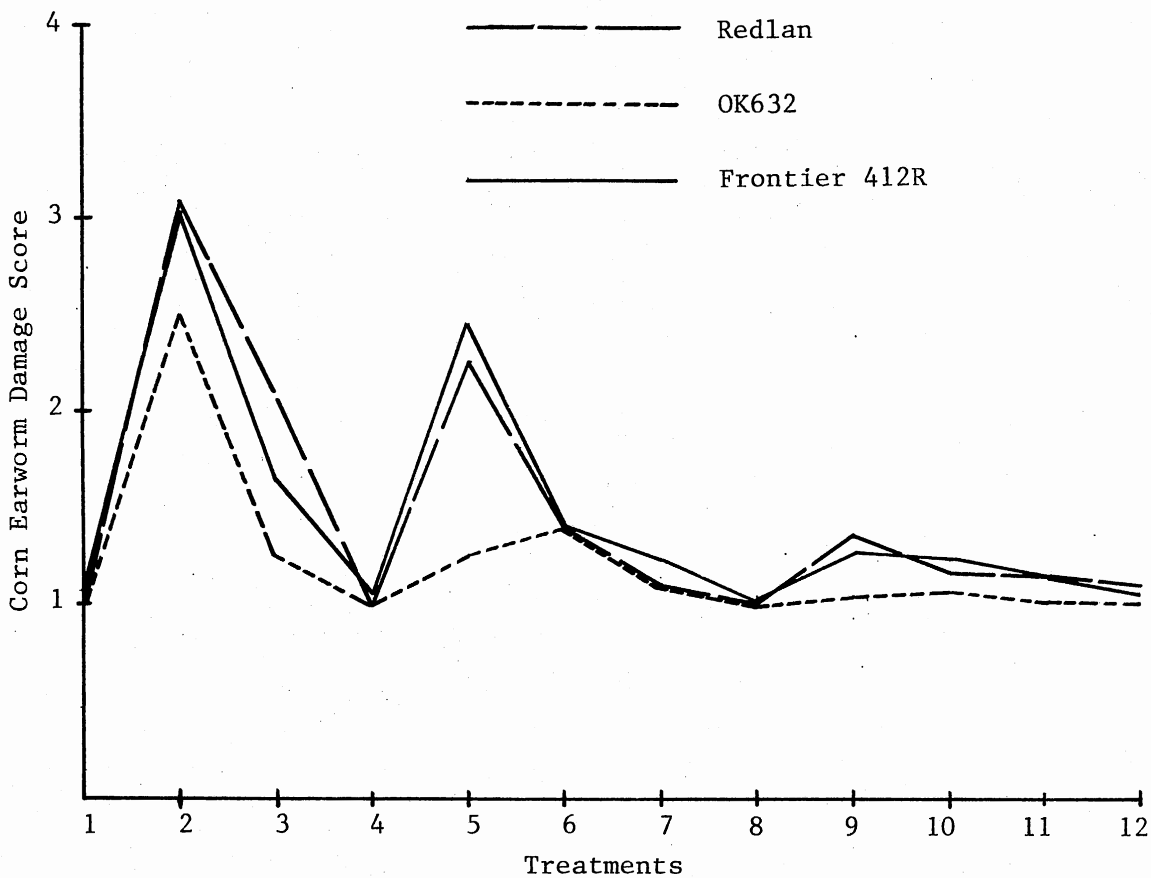

Figure 2. Comparison of the Means of the Three Varieties for Corn Earworm Damage

produced the least amount of corn earworm damage, but it was not significantly different from treatments 1, 4, 7, 9, 10, 11, and 12. Treatment 6 (Methomyl injected) gave a level of control not different from treatments 7, 9, 10, and 11.

Corn Earworm Holes Per Bag

The analysis of variance for this variable showed significance for variety X treatment interaction (Table IX), therefore, the means for each variety will be discussed. Tables VI, VII, and VIII show the means and Duncan's Multiple Range Tests for Redlan, OK632, and Frontier 412R, respectively.

For the variety Redlan, treatment 5 (Sevin + Pirimor dipped) had a significantly higher mean than treatment 2, which had a significantly higher mean than all the other treatments except 3. There was no significant differences among any of the remaining treatments. The variety Frontier 412R (Table VIII) followed a similar trend to Redlan except that treatment 5 was not significantly different from treatment 2. The other treatments did not show any significant differences. There was a different pattern with OK632 (Table VII). Treatment 2 was significantly higher than all the other treatments. There was much overlapping in the grouping pattern of the other treatments. The different ranking of treatments for the three varieties probably produced the significant variety X treatment interaction. The nonsignificant mean square for treatments indicates the need for some caution in the interpretation of the Duncan's Multiple Range Test of the treatment means.

There seemed to be some relationship between the higher count of corn earworm holes and the high corn earworm damage. Frontier 412R had

TABLE VI

MEANS FOR CORN EARWORM HOLES PER BAG
FOR VARIETY REDLAN

Treatment	Mean	Duncan's Range
5	2.40	A[1]
2	1.50	B
3	0.73	BC
4	0.60	C
9	0.50	C
11	0.43	C
12	0.13	C
8	0.10	C
6	0.00	C
1	0.00	C
7	0.00	C
10	0.00	C
Overall Mean	0.53	

[1]Means with the same letter are not significantly different at the .05 significance level.

TABLE VII

MEANS FOR CORN EARWORM HOLES PER BAG FOR VARIETY OK632

Treatment	Mean	Duncan's Range
2	2.36	A[1]
5	1.46	B
12	1.16	BC
3	0.93	BCD
6	0.80	BCDE
8	0.63	BCDE
7	0.33	CDE
4	0.16	DE
11	0.13	DE
9	0.10	DE
1	0.00	E
10	0.00	E
Overall Mean	0.66	

[1]Means with the same letter are not significantly different at the .05 significance level.

TABLE VIII

MEANS FOR CORN EARWORM HOLES PER BAG
FOR VARIETY FRONTIER 412R

Treatment	Mean	Duncan's Range
5	3.03	A[1]
2	2.33	AB
12	1.93	B
3	0.86	C
11	0.70	C
9	0.56	C
10	0.23	C
7	0.13	C
6	0.00	C
4	0.00	C
8	0.00	C
1	0.00	C
Overall Mean	0.81	

[1]Means with the same letter are not significantly different at the .05 significance level.

TABLE IX

ANALYSIS OF VARIANCE FOR CORN EARWORM HOLES PER BAG

Source	DF	MS	F Value
Total	107		
Replication	2	0.368	1.61
Variety	2	0.722	3.15
Treatment	11	5.330	23.26**
Variety X Treatment	22	0.566	2.47**
Error	70	0.229	

**Significant at the .01 level of significance.

the highest mean of corn earworm damage and also had the highest mean of corn earworm holes per bag. The distribution of the means for corn earworm holes per bag is presented graphically in Figure 3, and a comparison of the means of the three varieties in Figure 4. In all three varieties, treatment 5 (Sevin + Pirimor dipped) had the highest number of corn earworm holes of all the chemical treatments. This treatment also had the highest level of corn earworm damage of all the chemical treatments. Obviously, the higher number of corn earworm holes was associated with a higher level of corn earworm damage.

Corn Leaf Aphid Incidence

The means and analysis of variance for corn leaf aphid incidence are shown in Tables X and XI, respectively. The distribution of the treatment means are presented in Figure 5 and a comparison of the means of the three varieties in Figure 6. As indicated by Table XI, only treatments showed significance; variety and variety X treatment interaction did not. Therefore, only treatment means will be discussed.

Treatment 5 (Sevin + Pirimor dipped) produced the highest incidence of corn leaf aphid, but it was not significantly different from treatment 2 (untreated bags). Treatment 12 (Lindane + Malathion injected) produced the second to highest corn leaf aphid incidence score. Sevin + Pirimor dusted, Methomyl injected, Ambush + Malathion injected, Ambush + Diazinon injected, Diazinon dipped, and Malathion injected (treatments 4, 6, 7, 8, 9, and 10, respectively) produced corn leaf aphid incidences similar to treatment 1 (no bags) which had the lowest incidence. These treatments showed very little corn leaf aphid incidence in comparison to treatments 2, 5, and 12. Treatments 11 (Dipel + Pirimor dusted) and 3

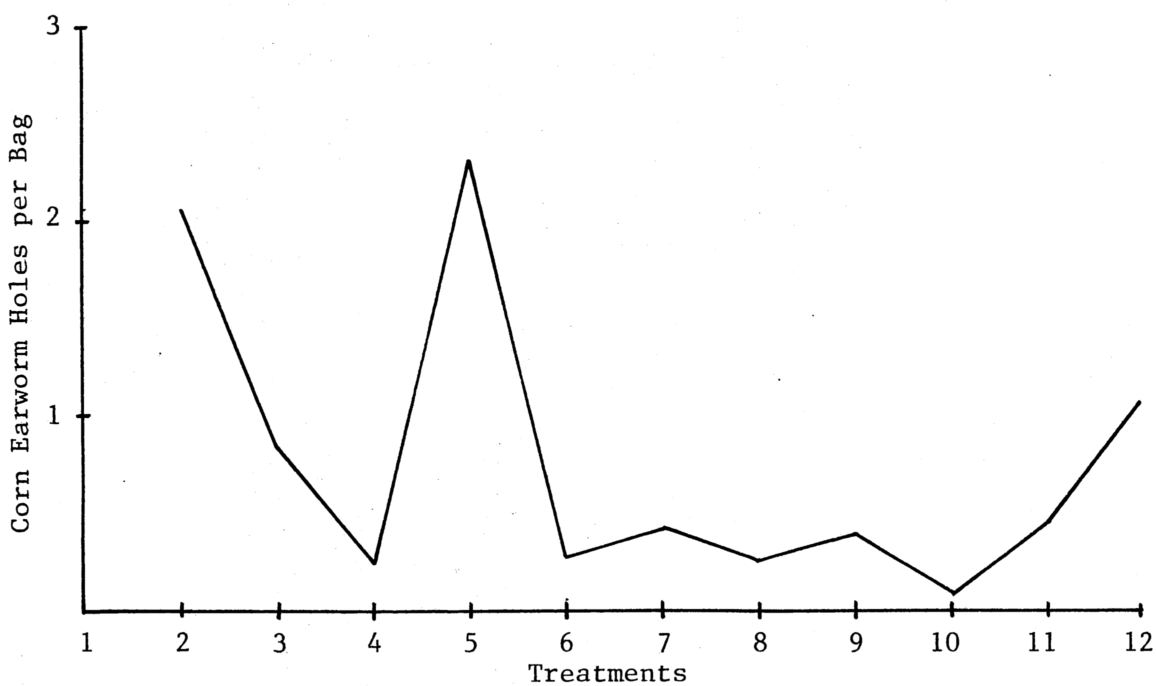

Figure 3. Distribution of Treatment Means for Corn Earworm Holes per Bag

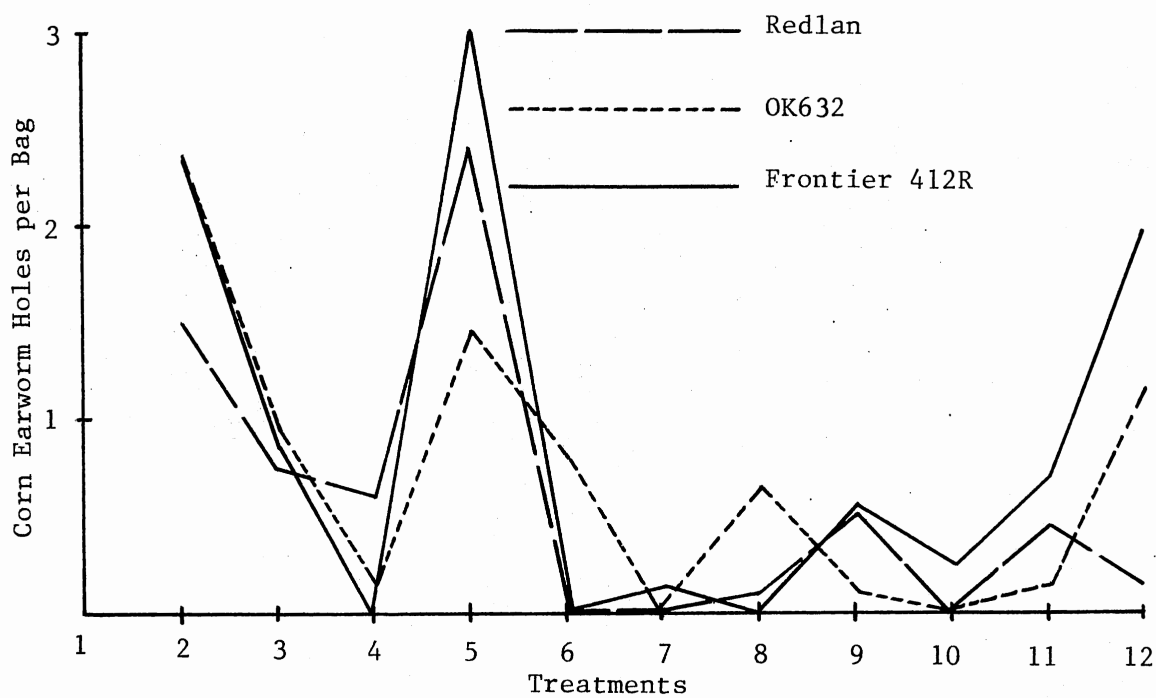

Figure 4. Comparison of the Means of the Three Varieties for Corn Earworm Holes per Bag

TABLE X

MEANS FOR CORN LEAF APHID INCIDENCE SCORES

Treatment	Variety			Mean	Duncan's Range
	Redlan	OK632	Frontier 412R		
5	3.50	2.26	3.36	3.10	A[1]
2	3.03	3.03	3.23	3.10	A
12	2.03	2.70	3.00	2.57	B
3	1.53	2.23	1.76	1.84	C
11	1.66	1.26	1.63	1.52	CD
9	1.50	1.20	1.56	1.42	DE
10	1.30	1.06	1.80	1.38	DE
4	1.43	1.23	1.20	1.28	DE
6	1.36	1.23	1.06	1.22	DE
8	1.13	1.26	1.23	1.21	DE
7	1.20	1.10	1.20	1.16	DE
1	1.10	1.00	1.13	1.07	E
Mean	1.73	1.65	1.85		

[1]Means with the same letter are not significantly different at the .05 significance level.

TABLE XI

ANALYSIS OF VARIANCE FOR CORN LEAF
APHID INCIDENCE SCORES

Source	DF	MS	F Value
Total	107		
Replication	2	0.367	2.68
Variety	2	0.363	2.65
Treatment	11	5.010	37.19**
Variety X Treatment	22	0.234	1.71
Error	70	0.137	

**Significant at the .01 level of significance.

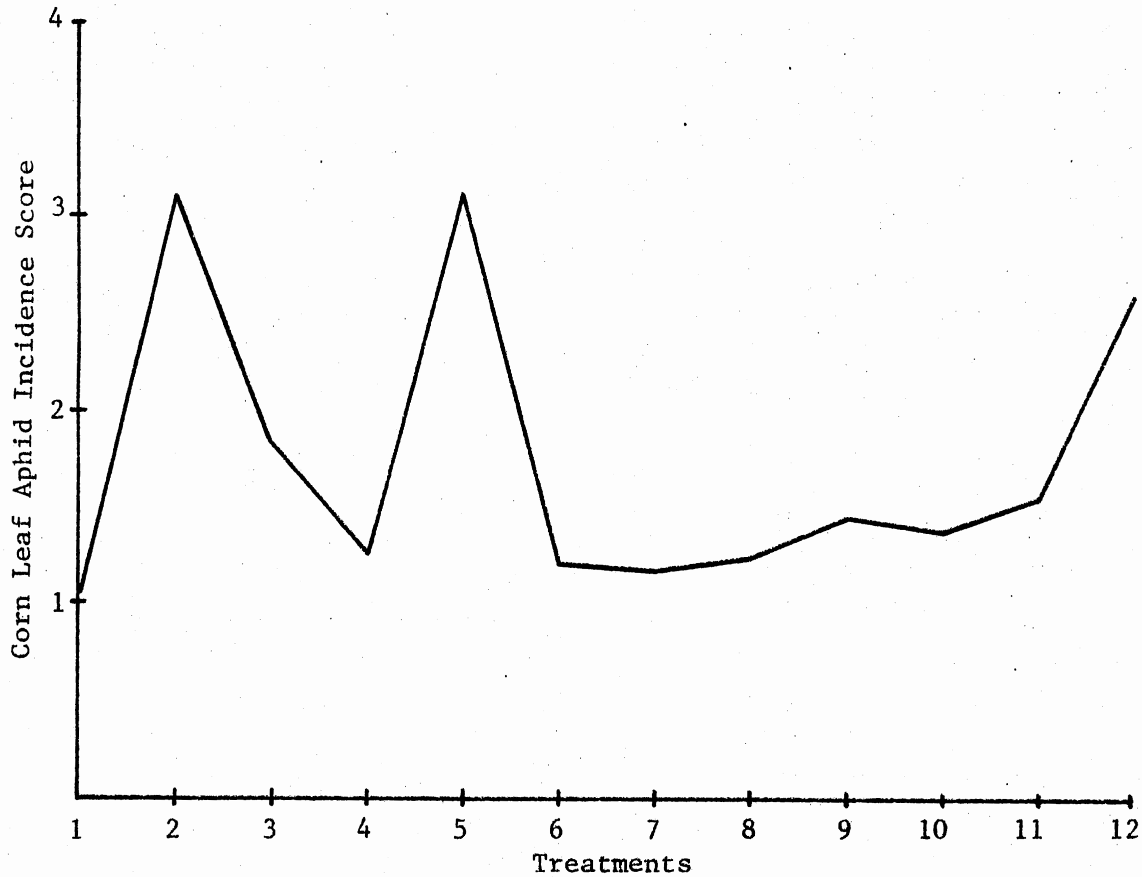

Figure 5. Distribution of Treatment Means for Corn Leaf Aphid Incidence

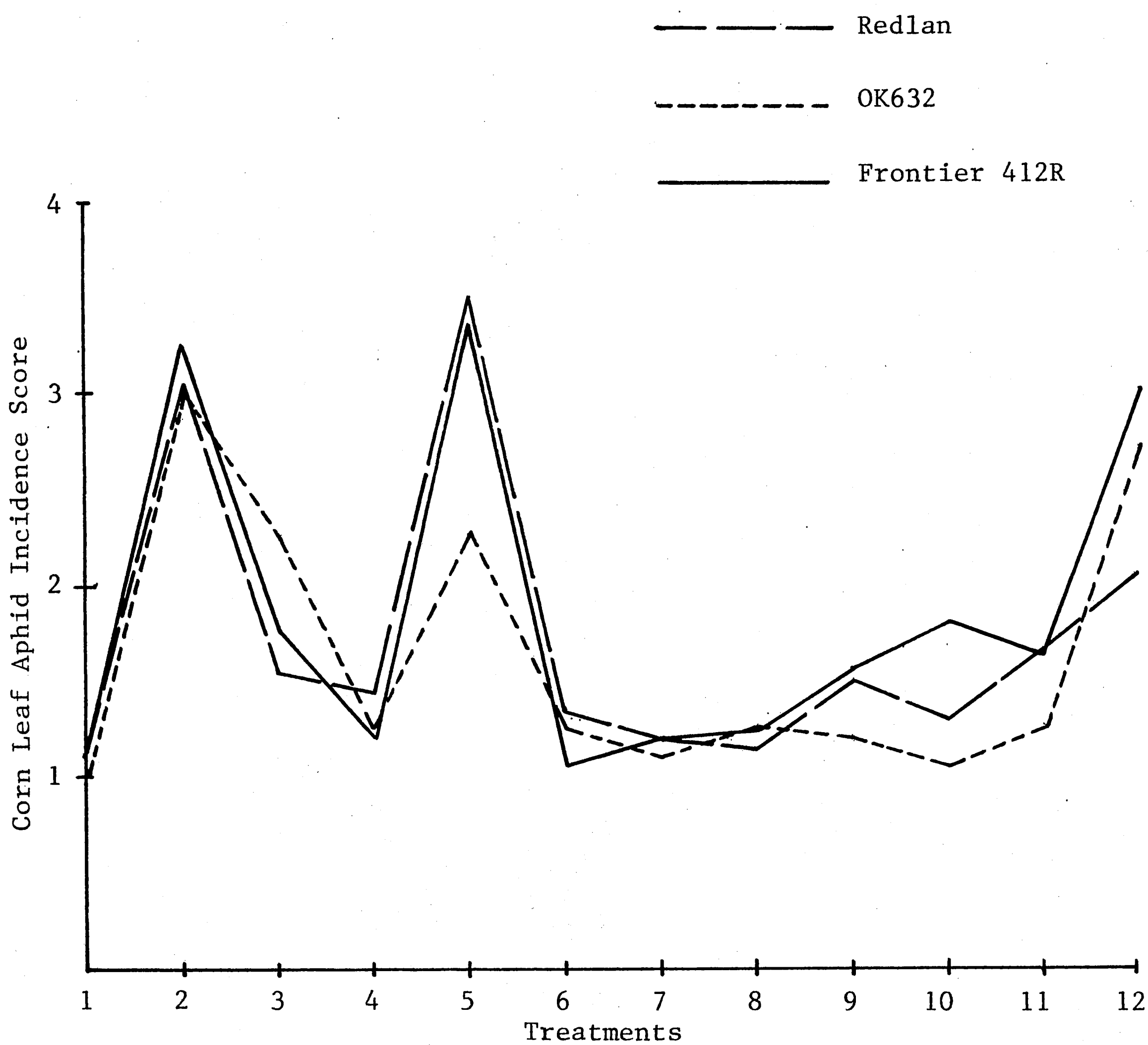

Figure 6. Comparison of the Means of the Three Varieties for Corn Leaf Aphid Incidence

(Toxaphene + Pirimor dipped) gave intermediate corn leaf aphid incidence scores.

Sterility

The means for sterility ratings and the analysis of variance for these means are shown in Tables XII and XIII, respectively. Figure 7 shows the distribution of the treatment means and Figure 8 shows a comparison of the means of the different varieties. The analysis of variance indicated significance for all the variables except variety X treatment interaction. The variety OK632 apparently had a lower mean sterility rating than Redlan and Frontier 412R.

Among the individual treatment means, Ambush + Diazinon injected (treatment 8) and Diazinon dipped (treatment 9) produced mean sterility ratings comparable to untreated bags (treatment 2) which had the highest mean. Toxaphene + Pirimor dipped, Sevin + Pirimor dusted, Methomyl injected, Ambush + Malathion injected, and Dipel + Pirimor dusted (treatments 3, 4, 6, 7, and 11, respectively) had mean sterility ratings which were not significantly different from treatment 1 (no bags). Treatment 1 had the lowest mean ratings. Treatment 4 produced the lowest sterility rating of all the chemical treatments, and treatment 8 produced the highest.

Treatment 8 and 9 are among the treatments which were most effective against the corn leaf aphid and are the treatments with the highest sterility ratings. Treatment 8 also gave good control of the corn earworm. Treatments 4 and 7 were the only two treatments which gave good control of both the corn earworm and corn leaf aphid while producing low sterility. Treatment 3 was among the treatments with the lowest

TABLE XII

MEANS FOR STERILITY RATINGS

Treatment	Variety: Redlan	Variety: OK632	Variety: Frontier 412R	Mean	Duncan's Range
2	3.26	1.90	1.73	2.30	A[1]
8	3.16	1.30	2.06	2.17	AB
9	1.76	1.60	2.23	1.86	ABC
5	2.00	1.36	2.00	1.78	BCD
12	1.43	1.56	1.80	1.60	CDE
10	1.36	1.63	1.53	1.51	CDE
7	1.26	1.36	1.53	1.38	DEF
3	1.46	1.20	1.40	1.36	DEF
11	1.56	1.13	1.36	1.35	DEF
6	1.23	1.13	1.60	1.32	DEF
4	1.26	1.16	1.40	1.27	EF
1	1.00	1.00	1.00	1.00	F
Mean	1.71	1.36	1.63		
Duncan's Range	A	B	A		

[1]Means with the same letter are not significantly different at the .05 significance level.

TABLE XIII

ANALYSIS OF VARIANCE FOR STERILITY RATINGS

Source	DF	MS	F Value
Total	107		
Replication	2	0.458	2.33
Variety	2	1.236	6.28**
Treatment	11	1.414	7.19**
Variety X Treatment	22	0.450	2.29
Error	70	0.196	

**Significant at the .01 level of significance.

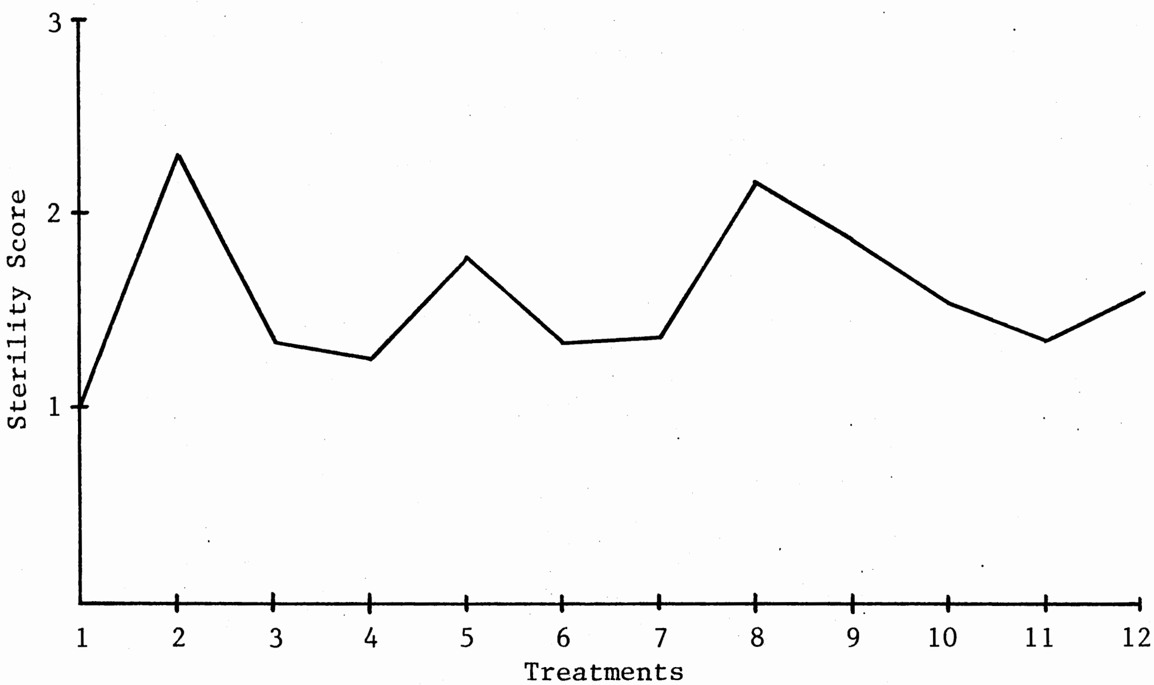

Figure 7. Distribution of Treatment Means for Sterility

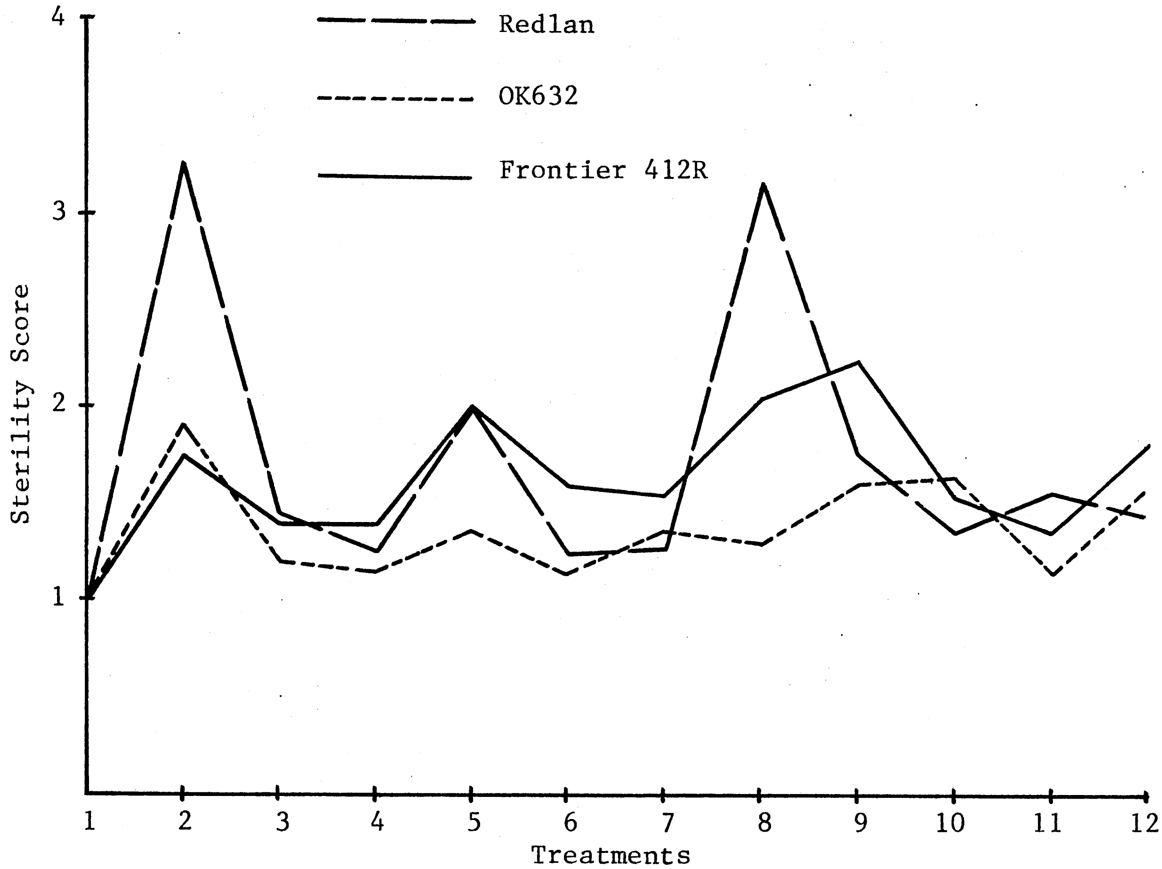

Figure 8. Comparison of the Means of the Three Varieties for Sterility

sterility rating, but was not among the treatments which gave the best control of either the corn earworm or corn leaf aphid. Treatment 11 gave good control of the corn earworm and also gave low sterility while treatment 6 gave good control of the corn leaf aphid and also gave low sterility.

If we use the amount of sterility produced to estimate phytotoxic effects of the chemicals by assuming that any treatment which produced a higher sterility rating than the check (untreated bags) shows phytotoxicity, then in this study none of the chemicals applied produced any phytotoxic effects. However, it was sometimes difficult to distinguish insect damage from sterility produced by the chemicals.

Threshing Percentage

The analysis of variance for threshing percentage (Table XV) indicated that there were significant differences among varieties and among treatments but the variety X treatment interaction was nonsignificant. The variety means for threshing percentage and Duncan's Multiple Range Test of these means are shown in Table XIV. The highest mean for a variety for threshing percentage was 71.2, and it was shown by OK632. This was significantly higher than Redlan and Frontier 412R. The lowest threshing percentage was 67.4 for Redlan, but this was not significantly different from Frontier 412R.

The treatment means (Table XIV) showed that treatment 7 (Ambush + Malathion injected) produced the highest threshing percentage, but it was not significantly different from treatments 1, 3, 4, 6, 8, 9, 10, and 11. All the treatments which gave low sterility are among the set of treatments which gave high threshing percentage. All the treatments

TABLE XIV

MEANS FOR THRESHING PERCENTAGE

Treatment	Variety: Redlan	Variety: OK632	Variety: Frontier 412R	Mean	Duncan's Range
	--------	%	--------		
7	76.3	69.3	72.4	72.6	A[1]
11	69.9	73.2	72.9	72.0	A
1	71.3	74.1	69.0	71.4	A
4	72.3	72.2	71.0	71.8	A
10	71.9	74.5	69.1	71.8	A
6	71.2	72.1	70.1	71.1	A
9	67.4	70.7	71.5	69.9	A
3	67.8	71.3	69.5	69.5	A
8	68.9	71.1	66.7	68.9	AB
12	60.7	71.9	60.6	64.4	BC
5	52.4	68.0	64.0	61.4	C
2	59.9	65.8	60.7	62.1	C
Mean	67.4	71.2	68.1		
Duncan's Range	B	A	B		

[1]Means with the same letter are not significantly different at the .05 significance level.

TABLE XV

ANALYSIS OF VARIANCE FOR THRESHING PERCENTAGE

Source	DF	MS	F Value
Total	107		
Replication	2	48.153	2.10
Variety	2	150.612	6.57**
Treatment	11	162.727	7.10**
Variety X Treatment	22	18.933	1.39
Error	70	24.187	

**Significant at the .01 level of significance.

which were among the highest in corn earworm control, except treatment 12, also fell within the group which gave high threshing percentage. All the treatments which produced low corn leaf aphid incidence, except treatment 8, also fell within this group. Treatment 2 (untreated bags) gave the lowest threshing percentage which was not significantly different from treatment 5 (Sevin + Pirimor dipped) and treatment 12 (Lindane + Malathion injected). These are the same treatments which produced high corn earworm damage and high corn leaf aphid incidence. It seemed certain that high corn earworm damage and high corn leaf aphid incidence played some role in causing lower threshing percentage. The distribution of the treatment means for threshing percentage are shown in Figure 9, and a comparison of the means of the three varieties for threshing percentage is presented graphically in Figure 10.

Panicle Weight

The analysis of variance for panicle weight (Table XVII) indicated significant differences among varieties and among treatments, while variety X treatment interaction was nonsignificant. The means for panicle weight and Duncan's Multiple Range Test of the means for varieties and treatments are shown in Table XVI. Significant differences were indicated among all three varieties. Frontier 412R had the highest mean and Redlan had the lowest. Frontier 412R and OK632 are both hybrids and have a higher yield potential than Redlan which is not a hybrid. This probably accounts for the significantly lower panicle weight of Redlan. Figure 11 shows the distribution of the treatment means for panicle weight and Figure 12 gives a comparison of the means of the three varieties.

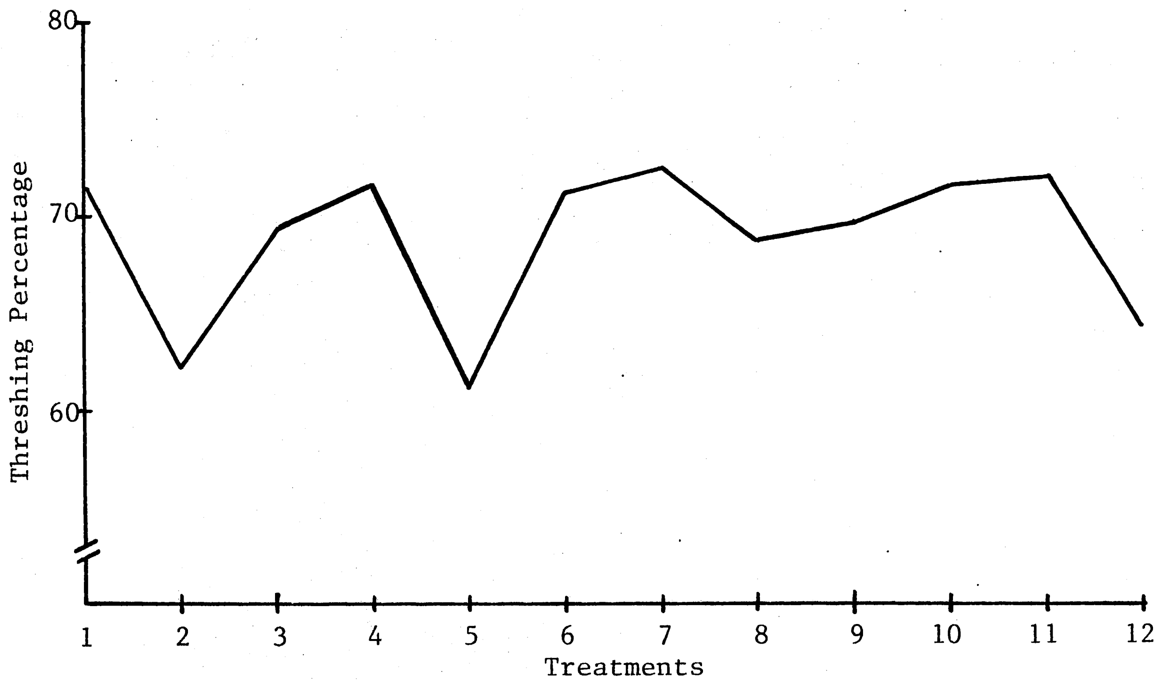

Figure 9. Distribution of Treatment Means for Threshing Percentage

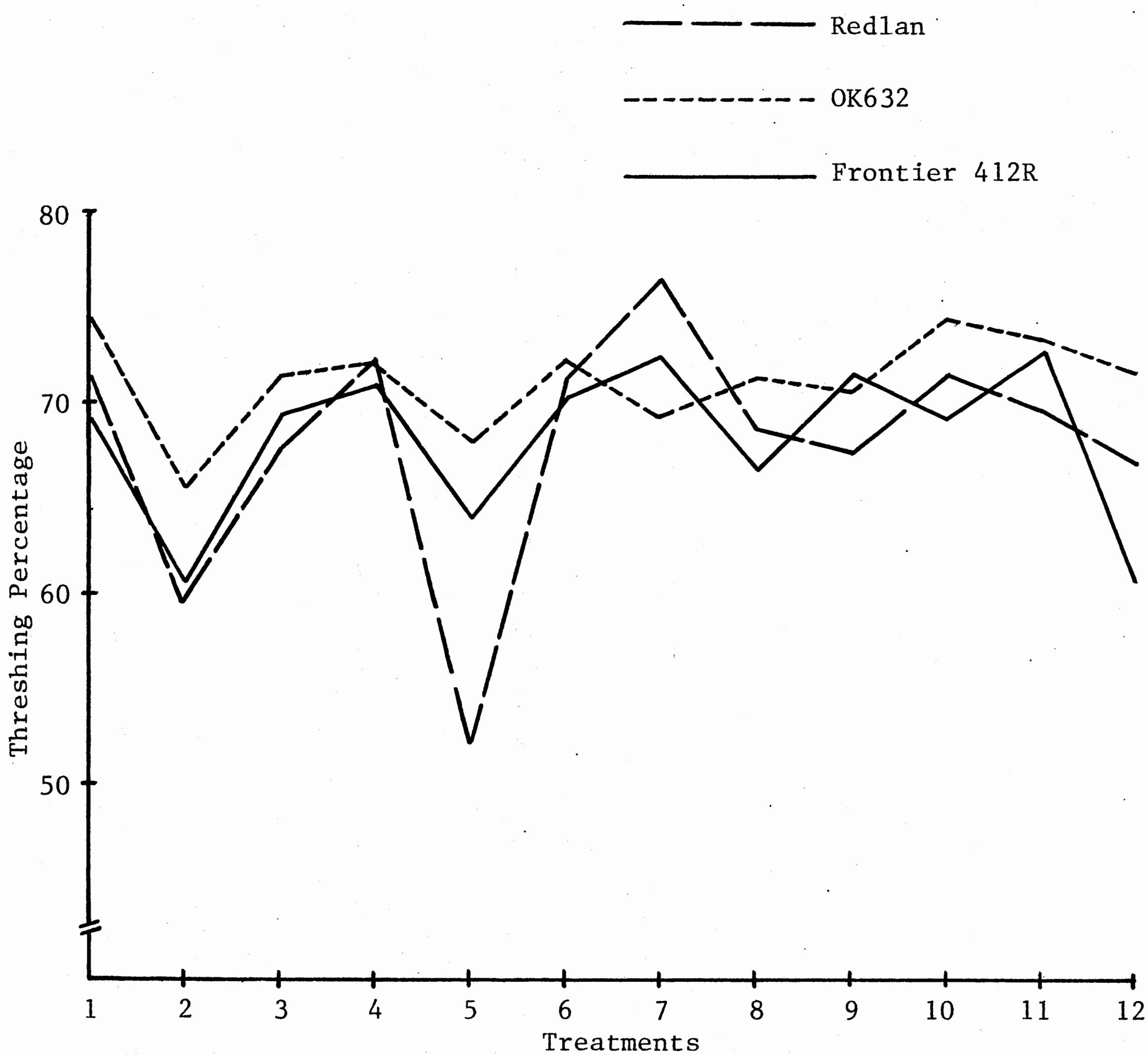

Figure 10. Comparison of the Means of the Three Varieties for Threshing Percentage

TABLE XVI

MEANS FOR PANICLE WEIGHT

Treatment	Variety: Redlan	OK632	Frontier 412R	Mean	Duncan's Range
	----------g----------				
4	65.0	80.1	97.9	81.0	A[1]
6	57.1	89.9	95.7	80.9	A
1	67.8	84.8	85.1	79.2	AB
11	48.3	86.6	93.0	76.0	ABC
7	55.3	79.1	90.0	74.8	ABCD
10	58.6	74.0	78.2	70.2	ABCDE
3	45.2	66.3	86.9	66.1	CDE
9	47.1	74.0	75.5	65.5	DE
2	33.8	74.0	87.3	65.0	DE
5	40.2	71.1	77.3	62.8	E
8	39.1	66.1	76.8	60.6	E
12	47.8	67.1	66.2	60.3	E
Mean	50.4	76.1	84.2		
Duncan's Range	C	B	A		

[1]Means with the same letter are not significantly different at the .05 significance level.

TABLE XVII

ANALYSIS OF VARIANCE FOR PANICLE WEIGHT

Source	DF	MS	F Value
Total	107		
Replication	2	808.492	8.67
Variety	2	11,163.387	119.76**
Treatment	11	550.795	5.91**
Variety X Treatment	22	122.117	1.31
Error	70	93.215	

**Significant at the .01 level of significance.

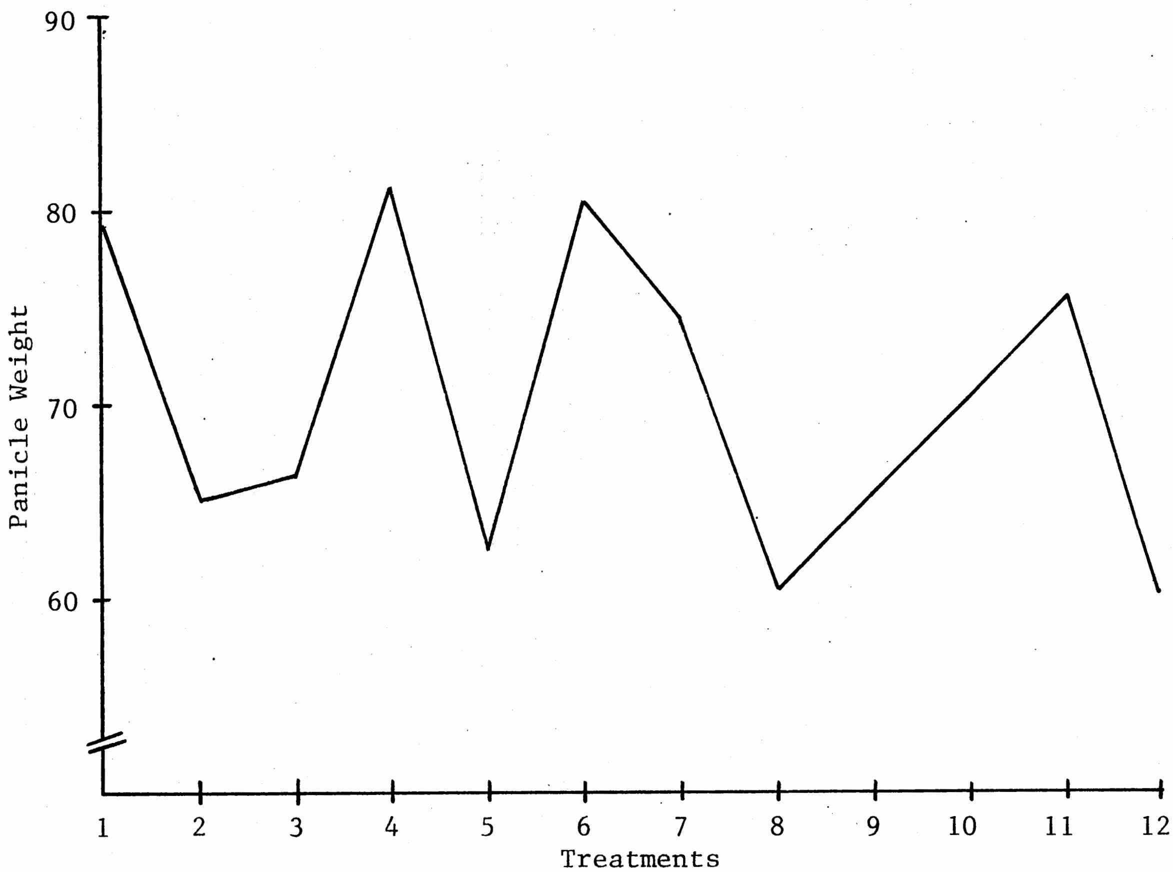

Figure 11. Distribution of Treatment Means for Panicle Weight

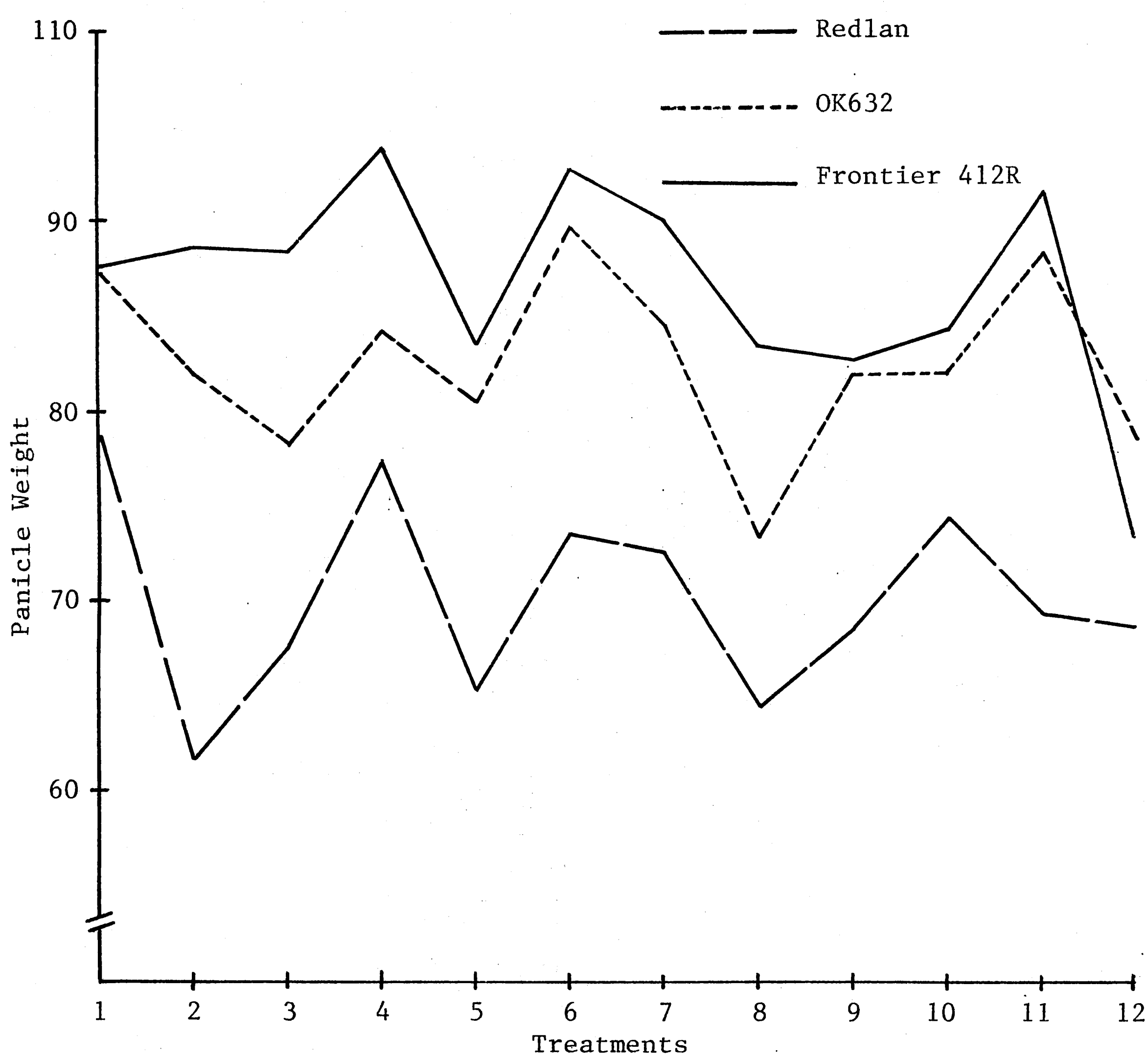

Figure 12. Comparison of the Means of the Three Varieties for Panicle Weight

Panicles treated with Lindane + Malathion injected (treatment 12), gave the lowest panicle weights. These were also the panicles with high corn earworm damage. Panicle weights produced by treatment 12 were not significantly different from those produced by treatments 2, 3, 5, 8, 9, and 10. Of these, treatment 2 (untreated bags) and treatment 5 (Sevin + Pirimor dipped) had a high level of corn earworm damage, while treatment 8 (Ambush + Diazinon injected) and treatment 9 (Diazinon injected) were the treatments which produced the highest level of sterility. This indicates that there was some relationship between panicle weight and corn earworm damage, as well as between panicle weight and sterility. Panicles which received treatment 4 (Sevin + Pirimor dusted) had the highest panicle weights, but they were not significantly different from treatments 1, 6, 7, 10, and 11. This is further supporting evidence for the above relationship, since treatments 7 and 11 were among those treatments with the best corn earworm control and treatments 1, 6, 7, and 11 were among the treatments which gave the lowest sterility.

Grain Weight per Panicle

The analysis of variance shown in Table XIX shows significance for variety and for treatment, but not for the variety X treatment interaction. The variety Frontier 412R had the highest grain weight per panicle, but was not significantly different from OK632. Redlan had a significantly lower grain weight per panicle than the others (Table XVIII). Figure 13 shows the distribution of the treatment means for grain weight per panicle and the means of the three varieties are compared in Figure 14. The 1980 growing season was quite droughty, and Redlan, a pure-line, seemed to have shown a more negative response to

TABLE XVIII

MEANS FOR GRAIN WEIGHT PER PANICLE

Treatment	Variety			Mean	Duncan's Range
	Redlan	OK632	Frontier 412R		
	--------------------	g	--------------------		
4	47.1	58.1	69.6	58.2	A[1]
6	40.8	64.8	67.2	57.6	AB
1	48.3	63.1	60.3	57.3	AB
11	33.9	63.4	67.9	55.0	AB
7	42.3	54.8	65.4	54.2	AB
10	42.2	55.1	53.7	50.3	BC
3	30.7	47.5	60.3	46.2	CD
9	31.7	52.0	54.0	45.9	CD
8	27.0	47.6	51.1	41.9	D
2	19.5	48.8	51.5	39.9	D
5	21.0	48.4	49.8	39.7	D
12	29.4	48.1	40.4	39.3	D
Mean	34.5	54.3	57.6		
Duncan's Range	B	A	A		

[1]Means with the same letter are not significantly different at the .05 significance level.

TABLE XIX

ANALYSIS OF VARIANCE FOR GRAIN WEIGHT PER PANICLE

Source	DF	MS	F Value
Total	107		
Replication	2	557.287	10.30
Variety	2	5,634.981	104.12**
Treatment	11	509.925	9.42**
Variety X Treatment	22	70.916	1.31
Error	70	54.119	

**Significant at the .01 level of significance.

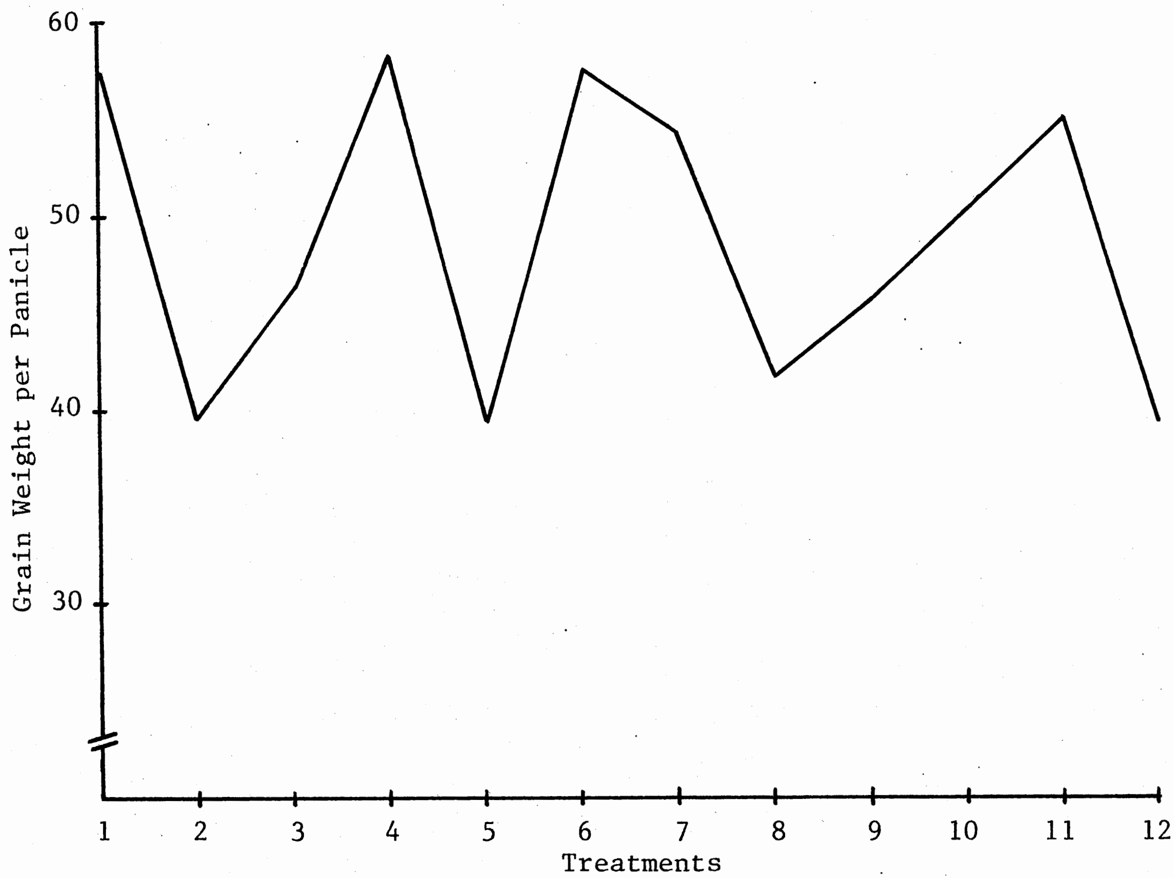

Figure 13. Distribution of the Treatment Means for Grain Weight per Panicle

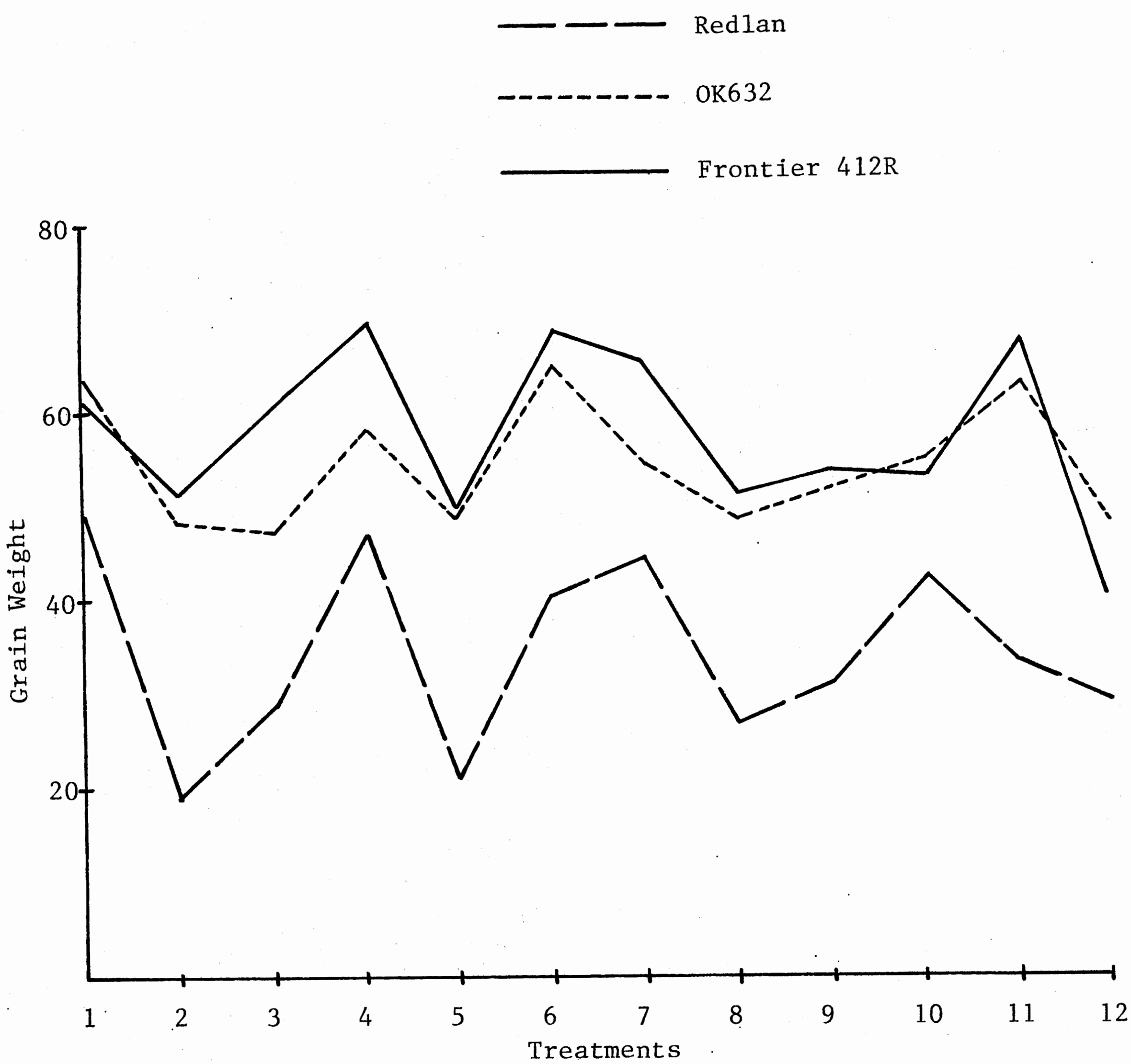

Figure 14. Comparison of the Means of the Three Varieties for Grain Weight per Panicle

the drought than the two hybrids. Panicle size of Redlan was smaller, and this accounted partially for the difference in grain weight per panicle. As discussed earlier in the chapter, varietal characteristics played a major role.

As expected, treatment 12 (Lindane + Malathion injected) which gave the lowest panicle weight, also gave the lowest grain weight per panicle. The grain weights produced by this treatment, however, were not significantly different from those produced by treatments 2, 3, 5, 8, and 9. Panicles which received treatment 2 (untreated bags) had the highest corn earworm damage, which accounted for the low grain weights per panicle. Panicles which received treatment 5 had significantly higher corn earworm damage than all other panicles except those receiving treatment 2, and so these panicles also had lower grain weight per panicle. The low grain weight per panicle produced by treatment 8 (Ambush + Diazinon injected) and treatment 9 (Diazinon injected) were probably associated with their higher sterility level. Consistent with the trend of grain weight per panicle produced by the treatments discussed, treatment 4 (Sevin + Pirimor dusted) produced the highest grain weight per panicle, and treatments 1, 6, 7, and 11 were not significantly different from treatment 4. These treatments had the lowest sterility ratings.

Weight of 100 Kernels

The analysis of variance for weight of 100 kernels (Table XXIII) showed significance for variety and for variety X treatment interaction and so individual variety means will be discussed. The means for each variety and Duncan's Multiple Range Test of these means are shown in Tables XX, XXI, and XXII.

TABLE XX

MEANS FOR WEIGHT OF 100 KERNELS FOR VARIETY REDLAN

Treatment	Mean	Duncan's Range
	-g-	
9	3.28	A
7	3.16	A
4	3.14	A
11	3.11	A
10	3.08	A
8	3.00	A
12	2.98	A
6	2.96	A
3	2.94	A
5	2.93	A
1	2.92	A
2	2.85	A
Overall Mean	3.03	

TABLE XXI

MEANS FOR WEIGHT OF 100 KERNELS FOR VARIETY OK632

Treatment	Mean	Duncan's Range
	--g--	
12	3.24	A[1]
1	3.23	A
2	2.94	AB
5	2.87	AB
10	2.78	ABC
3	2.70	BC
11	2.64	BC
9	2.58	BC
8	2.56	BC
4	2.52	BC
6	2.46	BC
7	2.30	C
Overall Mean	2.73	

[1]Means with the same letter are not significantly different at the .05 significance level.

TABLE XXII

MEANS FOR WEIGHT OF 100 KERNELS FOR VARIETY FRONTIER 412R

Treatment	Mean	Duncan's Range
	-g-	
2	3.76	A[1]
5	3.71	AB
9	3.70	AB
1	3.59	ABC
4	3.55	ABC
3	3.48	ABC
10	3.42	ABC
7	3.41	ABC
11	3.24	ABCD
12	3.20	BCD
6	3.14	CD
8	2.79	D
Overall Mean	3.41	

[1]Means with the same letter are not significantly different at the .05 significance level.

TABLE XXIII

ANALYSIS OF VARIANCE FOR WEIGHT OF 100 KERNELS

Source	DF	MS	F Value
Total	107		
Replication	2	0.277	3.64
Variety	2	4.199	55.08**
Treatment	11	0.180	2.37
Variety X Treatment	22	0.182	2.39**
Error	70	0.076	

**Significant at the .01 level of significance.

The grouping pattern of the treatments within the variety Frontier 412R showed much overlapping (Table XXII). Treatment 2 (untreated bags) had the highest mean and was only significantly different from treatments 6, 8, and 12. Treatment 8 (Ambush + Diazinon injected) had the lowest mean and was significantly different from all other treatments except treatments 6, 11, and 12. Within the variety OK632, treatment 12 (Lindane + Malathion injected) had the highest mean, but was not significantly different from 1, 2, 5, and 10 (Table XXI). Treatment 7 (Ambush + Malathion injected) had the lowest mean but was not significantly different from treatments 3, 4, 6, 8, 9, 10, and 11. These differences may not be meaningful since the mean square for treatments was nonsignificant. There were no significant differences among treatments within the variety Redlan (Table XX). The distribution of the means for weight of 100 kernels may be found in Figure 15 and a graphic comparison of the means of the three varieties is given in Figure 16.

Frontier 412R was the variety with the highest corn earworm damage and OK632 was the variety with the lowest corn earworm damage. It seemed, therefore, that with respect to varieties, where there were fewer kernels per panicle there was a higher weight of 100 kernels.

Germination Percentage

According to the analysis of variance for germination percentage (Table XXV) neither variety, treatment, nor variety X treatment interaction showed significant differences. The treatment means for germination percentage are shown in Table XXIV. Treatment 4 (Sevin + Pirimor dusted) gave the highest percentage of germination (94.7 percent). Treatment 6 (Methomyl injected) followed with a mean of 94.4 percent.

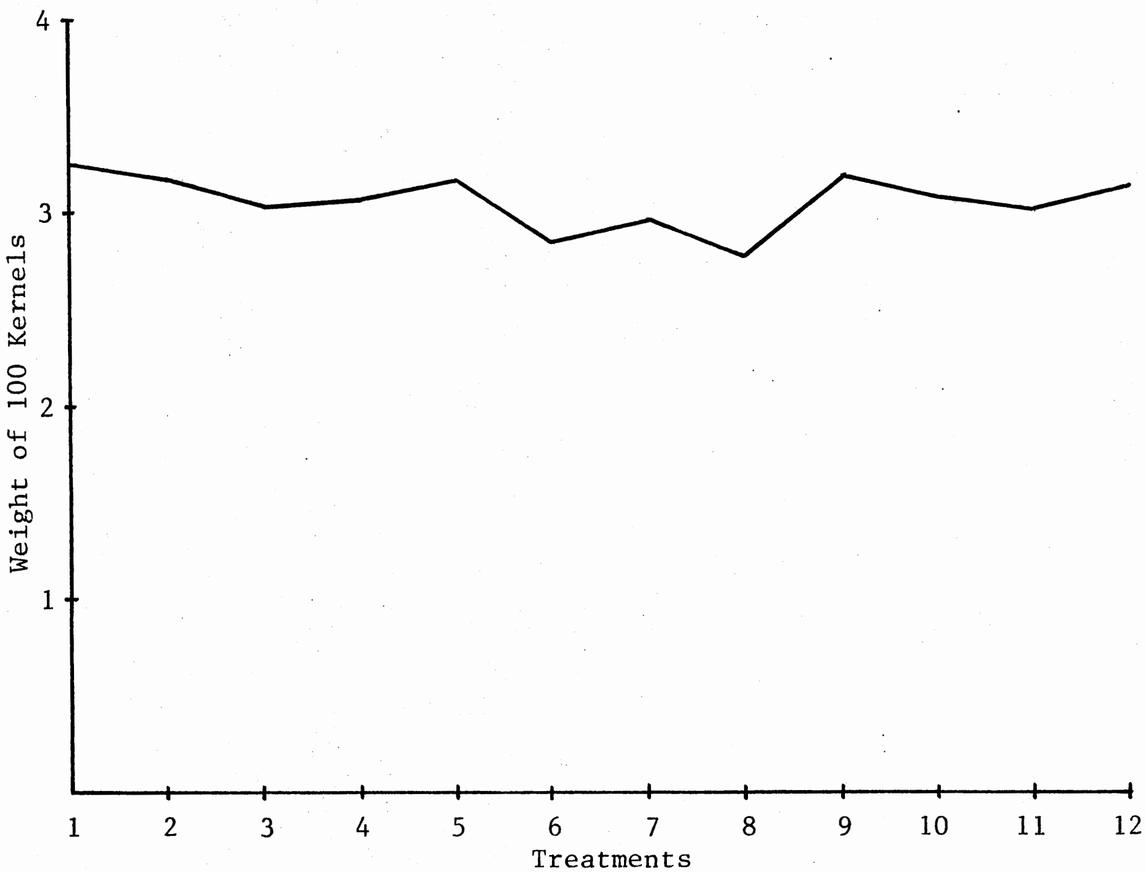

Figure 15. Distribution of Treatment Means for Weight of 100 Kernels

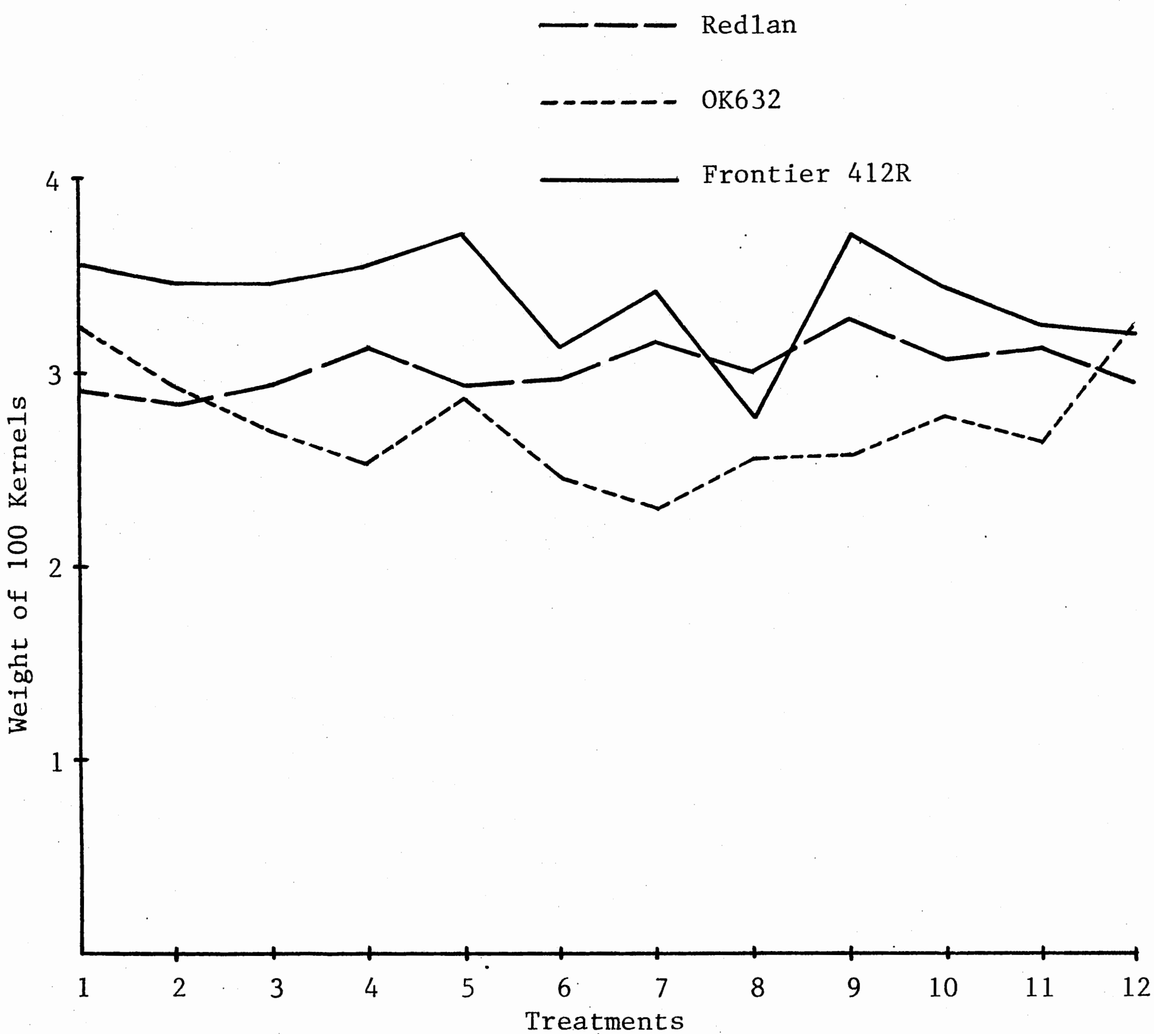

Figure 16. Comparison of the Means of the Three Varieties for Weight of 100 Kernels

TABLE XXIV

MEANS FOR GERMINATION PERCENTAGE

Treatment	Variety			Mean
	Redlan	OK632	Frontier 412R	
	%			
4	97.3	91.1	95.8	94.7
6	94.3	92.5	96.5	94.4
7	96.5	92.3	92.8	93.8
8	94.6	91.5	92.3	92.8
11	93.6	91.8	92.8	92.7
1	90.8	94.1	90.8	91.9
10	92.0	91.5	91.3	91.6
9	88.1	93.3	92.3	91.2
3	94.6	83.6	91.3	89.9
5	88.1	89.3	91.1	89.5
2	88.6	89.8	89.3	89.2
12	90.1	88.8	85.6	88.1
Mean	92.4	90.8	91.7	

TABLE XXV

ANALYSIS OF VARIANCE FOR GERMINATION PERCENTAGE

Source	DF	MS	F Value
Total	107		
Replication	2	35.111	1.45
Variety	2	23.090	0.95
Treatment	11	39.267	1.62
Variety X Treatment	22	18.933	0.78
Error	70	24.187	

These two treatments were not significantly different from any of the other treatments, however. The distribution of the treatment means are shown in Figure 17, and a comparison of the means of the three varieties in Figure 18. It appears that none of the chemical treatments applied to these three varieties impaired germination.

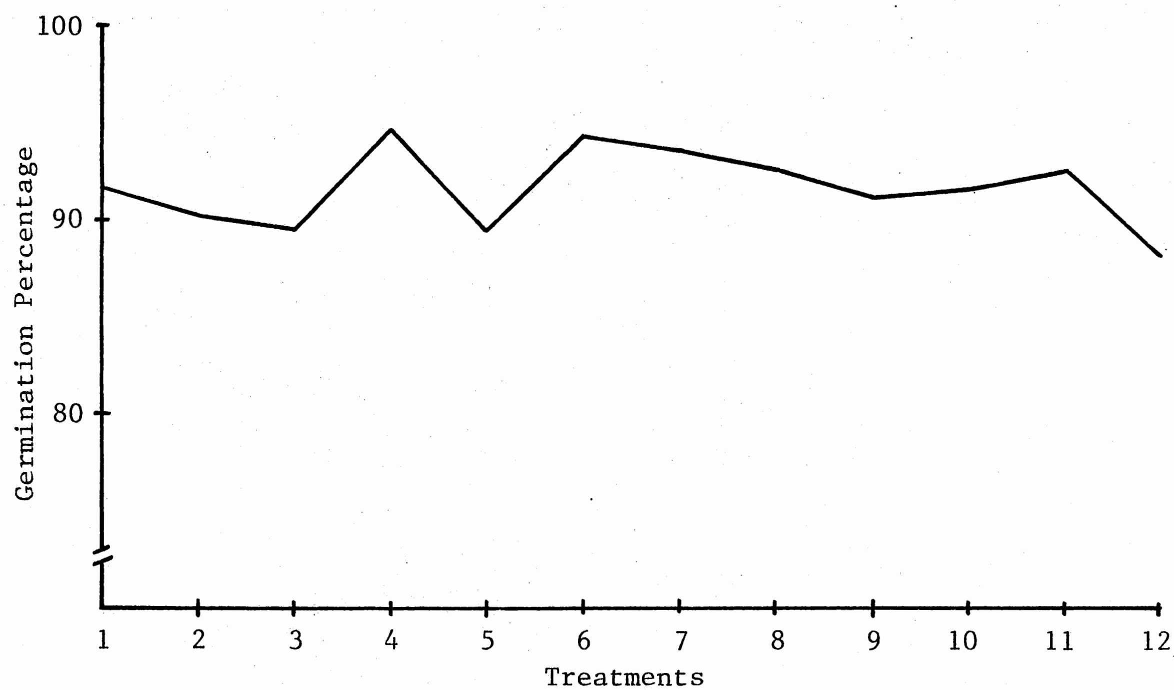

Figure 17. Distribution of Treatment Means for Germination Percentage

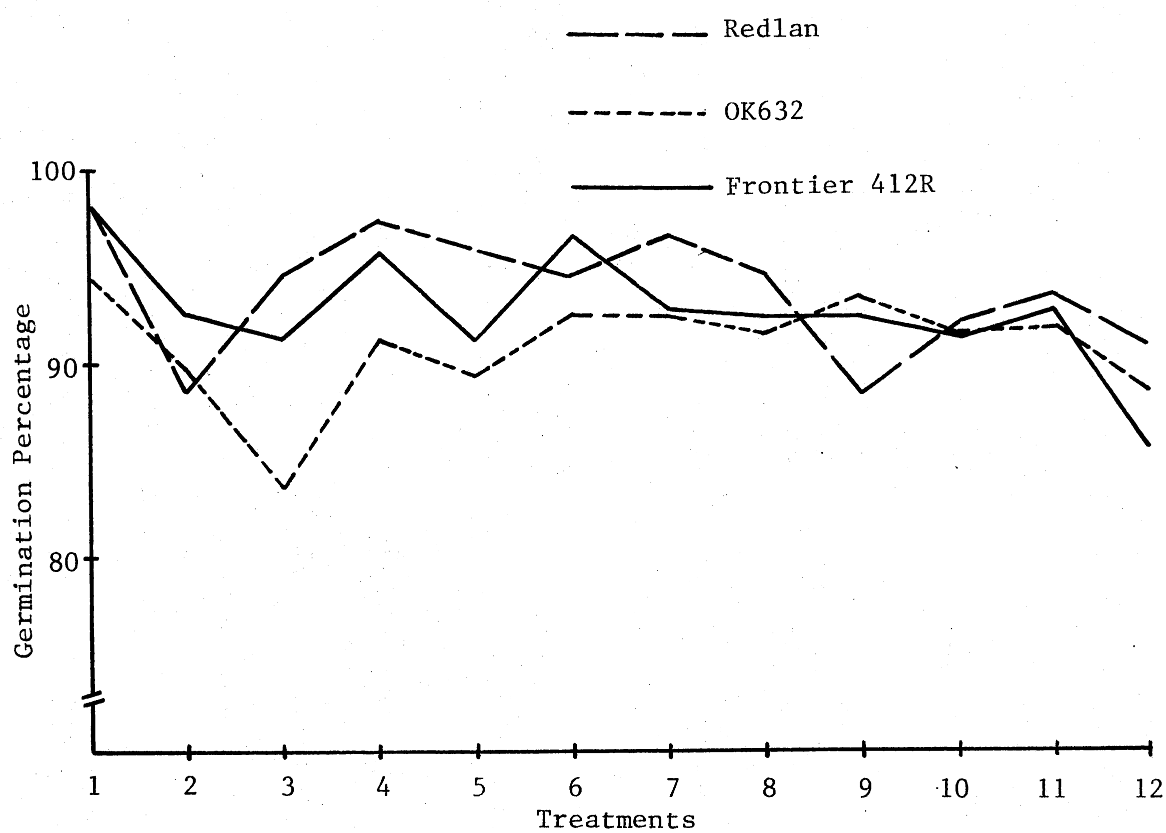

Figure 18. Comparison of the Means of the Three Varieties for Germination Percentage

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine the effects of certain insecticides on the control of the corn earworm and corn leaf aphid on grain sorghum under selfing-bag conditions in the field, and to evaluate the effects of these insecticides on some important plant traits.

Studies were conducted using nine different insecticides in different dosages and combinations. Twelve treatments, including checks, were applied to three different varieties of sorghum. Three methods of applying the treatments were adopted: dusting the inside of the bags with the insecticide, impregnating the bags with the insecticide by soaking, and spraying the insecticide directly onto the panicle after the selfing bag was put on.

The experiment was conducted using a randomized complete block design with three replications. A single row containing approximately 50 plants was used as an experimental unit. Twelve panicles were randomly selected from each row prior to blooming, and each was infested with day-old corn earworm larvae at a rate of about seven larvae per panicle. The panicles were covered with selfing bags which were allowed to remain over the panicle until harvest. Data for this experiment were obtained from only ten of the twelve panicles that were bagged. Nine variables were evaluated after harvest: corn earworm damage, corn leaf aphid incidence, corn earworm holes per bag, panicle weight, grain weight per panicle, threshing percentage, weight of 100 kernels, sterility, and germination percentage. Statistical analysis was done using Duncan's Multiple Range Test of the means following the analysis of variance.

The results showed significant differences among varieties at the 1% level for all the variables except for corn leaf aphid incidence and germination percentage. There were only three variables, corn earworm holes per bag, weight of 100 kernels, and germination percentage, that did not show significant differences among treatments at the 1% level. Significant interaction between variety and treatment were only found for corn earworm holes per bag and weight of 100 kernels.

Of the three varieties OK632 suffered the least amount of corn earworm damage, and Frontier 412R suffered the highest corn earworm damage, as well as the highest number of corn earworm holes per bag. Of the chemical treatments, treatment 5 (Sevin + Pirimor dipped) was the least effective against the corn earworm. Treatment 8 (Ambush + Diazinon injected) gave the best control of the corn earworm, but it was not significantly better than some of the other treatments. The results showed that a higher number of corn earworm holes was associated with greater corn earworm damage. Overall, none of the insecticides gave complete control of the corn earworm, but they all gave a control better than treatment 2 (untreated bags). All bagged panicles, treated and untreated, showed more corn earworm damage than the check (no bags).

With corn leaf aphid incidence there was no superior variety. All three varieties showed similar response to the treatments. None of the chemicals gave total control of the corn leaf aphid. However, all but treatments 3, 5, 11, and 12 gave a control similar to the check (no bag), and reduced corn leaf aphid incidence greatly. Treatment 5 (Sevin +

Pirimor dipped) was the least effective against the corn leaf aphid, followed by treatment 12 (Lindane + Malathion injected). Treatment 3 (Toxaphene + Pirimor dipped) and treatment 11 (Dipel + Pirimor dusted) gave only fair control of the corn leaf aphid.

There were two treatments with single insecticides that gave good control of both the corn earworm and the corn leaf aphid. These were treatment 9 (Diazinon dipped) and treatment 10 (Malathion injected). The two most effective combinations against both the corn earworm and corn leaf aphid were treatment 4 (Sevin + Pirimor dusted) and treatment 8 (Ambush + Diazinon injected).

OK632 showed the lowest sterility of the three varieties. Treatments which involved diazinon produced the highest sterility. Although it was not significantly lower than some other treatments, treatment 4 (Sevin + Pirimor dusted) produced the lowest sterility. Treatment 4 and treatment 7 (Ambush + Malathion injected) were the only two treatments which gave good control of both the corn earworm and corn leaf aphid, while producing low sterility.

None of the chemical treatments used showed any pronounced adverse effects on the plant traits considered. High corn earworm damage and corn leaf aphid incidence played some role in causing lower threshing percentages, but these percentages were not strikingly low. Panicle weight appeared consistent with variety, corn earworm damage, and sterility, while grain weight per panicle was consistent with panicle weight. Panicles with fewer kernels gave a higher weight of 100 kernels. None of the chemical treatments applied impaired germination.

Further studies are needed to determine: (a) the effectiveness of individual insecticide treatments or combinations against different instars of the corn earworm and (b) the effectiveness of individual insecticide treatments or combinations at different levels on the corn leaf aphid.

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