EFFECTS OF INSECTICIDE PLACEMENT ON HERBICIDE PHYTOTOXICITY TO SORGHUM

By

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PHYTOTOXICITY TO SORGHUM

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CHAPTER I

INTRODUCTION

With today's ever increasing demand for feed grains, there is a greater need for maximum production of sorghum. Pesticides such as s-triazine herbicides and organophosphorus insecticides are being used to increase sorghum (Sorghum bicolor L.) production. However, some crop injury has resulted from the use of insecticides and herbicides when both were applied as soil treatments for control of several insect and weed species.

Atrazine and propazine, two chloro-s-triazine herbicides and terbutryn, a methylthio-s-triazine, (chemical names of all herbicides are in Table I), have long been used in sorghum for preemergence weed control. Phorate and disulfoton (chemical names for all insecticides are listed in Table II) are insecticides currently used as soil treatments for sorghum insect control. Possible interaction of these herbicides and insecticides when both are used may cause stand reduction or injury to the sorghum. Some reports indicate that the phytotoxicity may be greater under stress growing conditions.

The purpose of this research was to evaluate the effects of combinations of the herbicides with insecticides in sorghum.

The objectives were:

(1) Compare the phytotoxicity of three s-triazine herbicides in conjunction with two organophosphate insecticides in

regard as to the phytotoxicity of the herbicides or insecticides alone.

(2) Evaluate the effects of various soil placements of the insecticides on their interaction with preemergence herbicides.

CHAPTER II

LITERATURE REVIEW

Combined applications of herbicides and insecticides are often made on a variety of crop species to control both weeds and insects. Each pesticide is usually restricted by law to certain crops which may be tolerant or show varying degrees of susceptibility to the chemical. Insecticides recommended for a crop are not usually harmful but when combined with a herbicide may cause an effect on the plant species which may not occur when either pesticide is used alone.

Combination interactions may also occur because of different placements of the insecticide in the soil in relation to the crop seed. Other factors that could possibly cause differential activity are formulation of the pesticide, and time span between application of the herbicide and insecticides. Very little research has been conducted to determine combination effects of pesticides on sorghum, however, much has been conducted using combinations of various insecticides and herbicides on cotton (Gossypium hirsutum), soybeans (Glycine max), oats (Avena sativa), and rice (Orysa sativa). Studies have been conducted using several chemical families of both herbicides and insecticides.

Insecticides have shown varying effects on herbicide phytotoxicity. Hacskaylo, et al. (10, 34) reported that combinations of either monuron or diuron with phorate or disulfoton definitely reduce the margin of safety and increase phytotoxicity as compared with either chemical used alone when all treatments were applied to cotton. Swanson and Swanson (33) have shown that photosynthetic oxygen evolution was unaffected by 4 X 10^{-4} M carbaryl. However, at 10^{-5} M carbaryl, there was marked inhibition of recovery of monuron-inhibited oxygen evolution and a 10^{-4} M carbaryl there was a complete prevention of recovery by monuron-treated cotton leaf discs. Thus, they postulated that the carbamate insecticide acts to prevent degradation of the photosynthetic inhibitor. The action of 4-benzothiphene-N-methylcarbamate was found to be the same as that of carbaryl, however, 2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate did not inhibit the ability of monuron-treated leaf discs to regain levels of oxygen evolution near that of the controls. It was found by Pires and Hacskaylo (30) that cotyledons of cotton seedlings developed marginal chlorotic areas about one week after emergence, followed quickly by cotyledon dessication and seedling death when phorate was applied as a seed-treatment and monuron as a pre-emergence treatment. The potential toxic effect resulting from the combined use of these insecticides and pre-emergence herbicides was found to be greater on light soils than on either heavy soil or sand.

Arle (1) found no differences in cotton seedling germination or growth during the four days following emergence upon treatment of phorate or disulfoton to soil with or without a herbicide treatment. However, secondary root development in the zone of herbicide incorporation was damaged less by several combinations of phorate or disulfoton with trifluralin than when trifluralin was used alone. Significant increases in numbers of secondary roots were obtained by each successive increase in rates of phorate or disulfoton in combination with trifluralin. Hassaway and Hamilton (14) also working with phorate and trifluralin combinations on cotton reported that germination was not affected by trifluralin, phorate or trifluralin-phorate combinations. Phorate significantly reduced dry shoot weight. This reduction of shoot weights by phorate or trifluralin-phorate combinations was related to the burning of the cotyledons and true leaves. Marginal burning and brownish spots were observed on the leaves at all rates of phorate. There was a significant interaction between trifluralin and phorate upon reduction of dry root weights. In the presence of phorate, root weight of trifluralin-treated plants was greater than that of plants that received trifluralin only.

Parks et al. (26) conducted studies on the effects of pesticides applied alone and in combination on cotton grown in Hoagland's solution. Phorate and disulfoton were found to have no harmful effect on the cotton when applied alone; however, phorate and disulfoton at 10 mg/ℓ decreased the intensity of trifluralin applied at 1 mg/ℓ. Several pesticides were evaluated by Chambers et al. (7) to study the possible injury to seedling cotton from applying combinations of pesticides at planting. Combinations of norea herbicide and phorate or disulfoton insecticides caused seedling injury over a wide range of soil and weather conditions. CIPC-insecticide combinations caused injury but to a lesser extent. Applying fluometuron or diuron with phorate or disulfoton caused injury in a few cases. Combining trifluralin and nitralin with insecticides improved plant vigor in several experiments. Using DCPA and prometryn with the systemic insecticides did not appear to cause seedling injury. Corbin and Bradley (8) found that phorate and disulfoton alone at 1 ppm were toxic to the seedlings. Growth reductions were not observed when herbicides were used alone but visible phytotoxic symptoms occurred from combinations of herbicides with insecticides. Delay in maturity and yield reductions were also observed for seed-furrow insecticides and for combinations of herbicide with insecticides at the most northerly location of a field study.

Ivy and Pfrimmer (17) observed that disulfoton treatments resulted in significantly higher seedling survival than phorate or UC-21149 (Aldicarb) when all insecticides were applied at 0.75 lb/acre in 1967. Herbicide-insecticide interactions on seedling survival and yield was not significant when trifluralin, nitralin, diuron, fluometuron, and norea were the herbicides used. Ivy and Savage (18, 32) reported that disulfoton significantly reduced cotton seedling mortality at phytotoxic fluometuron rates. Disulfoton tended to reduce chlorosis when applied in combination with 6 lb/acre fluometuron as compared to fluometuron applied alone. Yield was not significantly affected by fluometuron, or disulfoton or any combination of the two pesticides.

Effects of UC-21149 and commonly used herbicides on cotton were determined by Boling and Hacskaylo (2). Diuron and DCPA did not appear to affect growth adversely when applied alone or in combination with UC-21149. Trifluralin and CIPC caused a reduction in height in the seedlings when applied alone or in combination with UC-21149. This indicated that UC-21149 can be employed safely in combination with the herbicides DCPA, diuron, CIPC and trifluralin.

Helmer et al. (16) reported that cotton emergence, growth, and root development were variable when treated with trifluralin and in-furrow applications of systemic insecticides. Trifluralin in combination with disulfoton, phorate, or temik caused no reduction in the yield of cotton.

Pesticide combinations have also been studied on soybeans. Johnson (19, 20) reported no significant interactions occurred from pesticide combinations applied 20 days after planting in 1967. However, plant vigor was lower from amiben methyl ester applied alone than when applied in combination with selected systemic insecticides. Reductions in vigor also occurred from the combination of disulfoton plus trifluralin, but not significantly lower than from disulfoton alone. These variations in vigor of soybean seedlings induced by pesticides alone or in combination did not affect mature soybeans. In 1948, there was significant interaction noticed 15 days after planting when linuron was applied in combination with disulfoton as the vigor was lower from this combination than when each pesticide was applied alone. However, the effect was no longer present 30 days after planting.

Greenhouse experiments by Penner (29) indicated that the simultaneous preemergence application of disulfoton with atrazine increased injury, whereas if the insecticide was applied 14 days after atrazine, death of the soybean was delayed. Radioautographs indicated that disulfoton, diazinon, and fensulfothon all enhanced the accumulation of atrazine in the primary leaves of the soybean. Johnson and Jellum (21) reported that pesticide treatments applied alone or in combination to soybeans did not affect oil or protein content or fatty acid decomposition of oil in soybean seed.

Combinations of diuron with disulfoton or phorate in soil resulted in synergistic phytotoxicity as reported by Nash (24, 25). The phytotoxicity persisted longer where oats was the bioassay plant than when corn was used. The persistence of the combined pesticides corresponded closely with persistence of the individual pesticides. Nash (24) also reported that a combination of dalapon with disulfoton, phorate, or carbaryl in the soil resulted in additive phytotoxic effects to oats.

Studies were conducted by Bowling and Hudgins (3) to determine the compatability of several insecticides with the herbicide propanil for use as spray applications on rice. They reported that the insecticides aldrin, dieldrin, heptachlor, thiodan and D.D.T. applied along and in combination with propanil did not significantly reduce yields. A mixture of carbaryl and propanil caused severe leafburn, stand reduction and highly significant yield losses. Bowling and Hodgins (4) also found that toxaphene and endrin, in combination with propanil, did not increase leaf burn over that which occurred from propanil alone. Malathion, phosphamidon, azinphos-methyl and trichlorfon, in combination with propanil, increased leaf burn over that which occurred from propanil alone. In general, increased leaf burn resulted in decreased yields of rough rice. EL-Refai and Mowafy (9) reported that when propanil was applied in the presence of diazinon, no additive phytotoxicity occurred on rice plants over that occurring from propanil alone. Synergistic effects in rice, resulting in dry weight loss, were seen when soil was treated with 5 mg of diazinon per Kg of soil and subsequently sprayed with propanil. Synergistic phytotoxicity was apparent when propanil was applied one day after carbaryl treatment and most plants were killed but only slight injury was noticed when propanil was treated two weeks after carbaryl treatment. Matsunaka (23) reported that propanil hydrolysis by rice plants is inhibited by insecticides, with organophosphate insecticides inhibiting hydrolysis stronger than organothiophosphates. He concluded that the injury to rice plants by insecticides sprayed on them with propanil seemed to be caused by the inhibition of the propanil detoxifying enzyme.

The combination of the herbicide alachlor with the insecticide carbofuran was studied by Hamill and Penner (11). They reported that the combination acted synergistically to reduce barley but not corn growth. Radical length of barley seedlings was also reported by Hamill and Penner (13) to be greatly reduced by the combination of butylate and carbofuran. Corn seedlings were not similarly affected. However, they reported (12) that the combination of chlorbromuron and carbofuran synergistically reduced radical length in barley seedlings and also reduced the leaf area and dry-weight of 7-day-old corn seedlings grown in sand culture.

Hauser and Buchanan (15) reported non-significant insecticide x herbicide interactions when disulfoton and several herbicides were both applied to peanuts. Cargill and Santelmann (6) reported no apparent herbicide-insecticide interactions when disulfoton or phorate were applied to peanuts in combination with chloramben or trifluralin.

The effects of eight insecticides on the metabolism of the herbicides were investigated by Chang, Smith and Stephenson (5). The metabolism of dicamba, chlorpropham, and linuron in wheat, beans, and plantain, respectively, was commonly inhibited by organophosphate insecticides. Propanil was strongly inhibited by all the insecticides examined, especially the carbamates. No insecticides significantly inhibited the metabolism of chloramben, amitrole or 2,4-DB in bean.

Kirby and Santelmann (22) reported that tank mixtures of herbicide-insecticide combinations had different effects on the phytotoxicity of the herbicide depending upon the combination used. Some combinations had no effect while others would increase or decrease the phytotoxicity of the herbicide.

Parks, Truelove, and Buchanan (27, 28) found that prometryn inhibited state 3 respiration in etiolated bean mitochondria. Phorate also inhibited state 3 respiration. There were no significant interactions affecting state 3 respiration between phorate and prometryn at any of the concentrations evaluated.

Little research has been conducted to determine the effects of combinations of herbicides and insecticides applied to sorghum. Russ and TenEyck (31) conducted studies using disulfoton and several herbicides used in combination on grain sorghum. They reported that disulfoton appeared to be compatible with the herbicide propachlor. Combinations of disulfoton and norea, norea and atrazine, norea and propazine, and terbutryn should be avoided. In addition, little research has been conducted to determine the effects of the insecticide placement in the soil. This field research was conducted to determine the effect of combinations of s-triazine herbicides and organophosphate insecticides on sorghum with placement of the insecticide in relation to the seed also considered.

TABLE I

COMMON AND CHEMICAL NAMES OF HERBICIDES

Common Names	Chemical Names
alachlor	2-chloro-2',6' diethyl-N-(methoxy-methyl) acetanilide
amiben methyl ester	3-amino-2,5-dichlorobenzoic acid
amitrole	3-amino-s-triazole
atrazine	2-chloro-4-ethylamino-6-isopropyl-amino-s-triazine
butylate	S-ethyl diisobutylthiocarbamate
chloramben	3-amino-2,5-dichlorobenzoic acid
chlorbromuron	3-(4-bromo-3-chlorophenyl)-1-methoxy-1-methylurea
chlorpropham	isopropyl m-chlorocarbanilate
CIPC	isopropyl N-(3-chlorophenyl) carbamate
dalapon	2,2-dichloropropionic acid
DCPA	dimethyl tetrachloroterephthalate
dicamba	3,6-dichloro-O-anisic acid
diuron	3-(3,4-dichlorophenyl)-1,1-dimethyl-urea
fluometuron	1,1-dimethyl-3-(α,α,α,-trifluoro-m-tolyl) urea
linuron	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea
moruron	3-(p-chlorophenyl)-1,1-dimethylurea
nitralin	4-(methylsulfonyl)-2,6-dinitro-N, N-dipropylaniline
norea	3-(hexahydro-4,7-methenoindan-5-yl)-1,1-dimethylurea
prometryn	2,4-bis(isopropylamino)-6-(methyl-thio)-s-triazine
propachlor	2-chloro-N-isopropylacetanilide
propanil	3',4'-dichloropropionanilide
propazine	2-chloro-4,6-bis(isopropylamino)-s-triazine
terbutryn	2-(tert-butylamino)-4-(ethylamino)-6-(methylthip)-s-triazine
trifluralin	α,α,α-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine
2,4-DB	4-(2,4-dichlorophenoxy)butyric acid

TABLE II

COMMON AND CHEMICAL NAMES OF INSECTICIDES

Common Names	Chemical Names
aldicarb	2-methyl-2(methylthio)propionaldehyde O-(methylcarbamoyl)oxine
aldrin	1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-endo,exo-5,8-dimethanonaphthalene
azinphos-methyl	O,O-dimethyl S-(4-oxo-1,2,3-benzo-triazine-3 (4H)-yl)methyl) phosphorodithioate
carbaryl	1-naphthyl N-methylcarbamate
carbofuran	2,3-dihydro-2,2-dimethyl-7-benzo-furanyl methylcarbamate
DDT	dichlorodiphenyltrichloroethane
diazinon	O,O-diethyl O-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate
dieldrin	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,5,7,8,8a,-octahydro-1,4-endo, exo-5,8-dimethanonaphthalene
disulfoton	O,O-diethyl S-(2-(ethythio)ethyl) phosphorodithioate
endrin	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-ocahydro-1,4-endo-endo 5,8-dimethanonaphtalene
fensulfothion	O,O-diethyl O-{p-(methylsulfinyl) phenyl} phosphorothioate
heptachlor	1,4,5,6,7,8-Heptachloro-3a,4,7,7a-tetrahydro-4, 7-methanoindene
malathion	O,O-dimethylphosphorodithioate of diethylmercaptosuccinate
phorate	O,O-diethyl S- (ethylthio)-methyl phosphorodithioate
phosphamidon	2-chloro-N,N-diethyl-3-hydroxycro tonamide dimethylphosphate
thiodan	6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hydro-6,9-methano-2,4,3-benzo(e)-dioxathiepin-3-oxide
toxaphene	a mixture of octachloro camphene isomers
trichlorfon	dimethyl(2,2,2-trichloro-1-hydroxyethyl) phosphonate

CHAPTER III

MATERIALS AND METHODS

Field experiments were conducted on the Agronomy Research Station at Perkins, and Alva, Oklahoma in May, 1974 to evaluate potential injury to sorghum (Sorghum vulgare L. 'TEY 101') of combinations of s-triazine herbicides and organophosphate insecticides when both are applied as soil treatments.

The insecticides were applied at planting with a 2-row planter having an insecticide applicator attached. Phorate at 0, 1, and 2 pounds active ingredient per acre based on running feet per acre (lb/A) and disulfoton at 0, .75, and 1.5 lb/A were placed in the soil at three positions relative to the seed: 1. as a 7" band over the seed at the surface of the soil; 2. mixed with the seed; 3. as a 1 inch band placed 1½ inches to the side and at the same depth as the seed. Three days after planting, atrazine at 0, 1, and 2 lbs/A or propazine or terbutryn at 0, 2, and 4 lb/A were applied as preemergence treatments with an experimental-plot tractor sprayer. A split-split-split-plot design was used with soil placement of the insecticide as the main plot, herbicide treatment as the sub-plot and insecticide treatment as the sub-sub-plot with three replications per treatment. The plots were 2 rows wide by 15 feet long with the herbicides being sprayed across the rows. The soils were a Teller sandy loam and a Yahola very fine sandy loam at Perkins and Alva, respectively. Soil temperatures at planting time were 80°F and 75°F at Perkins and Alva, respectively. The rainfall for the growing season between May 15 and September 15 was 17.80 and 9.26 inches for Perkins and Alva, respectively.

Plant Evaluations

Visual evaluations were made 15 and 46 days after the time of seeding at Perkins and 12 days after seeding date at Alva by estimating stand reduction and stunting of the sorghum plants. These estimations were made by two people, using a scale ranging from 0 to 10, with 0 being no stand reduction or stunting of the sorghum plants ranging up to 10 being complete stand reduction and/or severe stunting or death of the plants.

Each plot was counted for the number of sorghum plants surviving in 16 feet of row 32 days after planting. Five plants were randomly selected in each plot and measured for height to estimate the effect the treatments had on stunting.

At Perkins, the number of sorghum heads for two rows of eight feet were counted approximately 5 months after planting and averaged. Sorghum head counts were taken at harvest at Alva and these are the number of sorghum head per 16 feet of row. Sorghum head length was measured for five randomly selected heads from each plot at Perkins. Bird damage made grain harvest impractical so the head length was taken as a rough method of yield evaluation.

Birds caused some damage at Alva also but grain yield was taken by cutting the heads from sixteen feet of row. After drying the grain was harvested from the heads.

CHAPTER IV

RESULTS AND DISCUSSION

Visual ratings were made at Alva and Perkins approximately two weeks after plant emergence. These ratings are averages of three replications and were taken as the effects the treatments had on stand reduction and stunting or complete death of the sorghum. Atrazine in conjunction with phorate caused no significant herbicide by insecticide by placement interactions at the 5% level but there was significant insecticide by placement interaction (Table III). The greatest injury occurred when phorate at 2 lb/A was mixed with the seed at planting. Similar responses occurred at both ratings at Perkins (Tables IV and V). When atrazine was used over disulfoton at Alva, again there was more injury when disulfoton was placed with the seed at planting (Table VI). However at Perkins, there were no significant differences found among placements or between insecticide levels and placements (Tables IV and V).

Terbutryn was found to cause considerable damage to sorghum when used alone. Terbutryn by phorate by soil placement interactions on sorghum were significant at Alva (Table VI). The greatest injury occurred when terbutryn was present at 4 lbs/A in combination with phorate at 2 lbs/A placed over the seed or mixed with the seed. Visual ratings of herbicide by insecticide by soil placement interactions were not significant at Perkins but herbicide by insecticide interactions

TABLE III

INJURY EFFECTS OF PHORATE AT VARIOUS CONCENTRATIONS AND SOIL PLACEMENTS AT ALVA[1/]

Phorate (lbs/A)	Insecticide Placement		
	Over	With	Side
0	2[2/]	2	2
1	1	5	1
2	3	6	1

[1/]Data are averages of all atrazine treatment rates.

[2/]Visual ratings of 0-10 with 0 being no injury and 10 being complete plant kill.

TABLE IV

EARLY VISUAL INJURY RATINGS OF ALL TREATMENTS AT PERKINS

		Insecticide																	
		Phorate									Disulfoton								
		Over[1]			With			Side			Over			With			Side		
Herbicide	Rate	0[2]	1	2	0	1	2	0	1	2	0	3/4	1½	0	3/4	1½	0	3/4	1½
Atrazine	0	0[3]	0	4	0	2	4	0	1	0	0	0	0	0	0	0	0	0	0
Atrazine	1	2	2	5	3	6	6	3	3	2	1	2	2	3	4	4	2	2	2
Atrazine	2	6	6	8	5	6	8	6	6	6	6	6	6	5	5	5	5	6	6
Terbutryn	0	0	0	3	1	2	6	0	0	0	1	1	0	0	1	1	1	1	0
Terbutryn	2	5	8	9	3	8	9	4	6	5	6	7	7	1	5	5	4	6	6
Terbutryn	4	9	10	10	8	10	10	9	9	10	9	10	9	7	9	9	9	9	10
Propazine	0	1	1	2	0	1	3	1	0	0	0	1	1	0	0	0	0	1	0
Propazine	2	2	3	5	2	5	8	1	2	2	3	3	2	3	4	4	2	2	3
Propazine	4	5	4	6	3	4	7	4	4	3	4	3	4	2	2	3	4	3	3

[1] Insecticide placement in relation to the seed.

[2] Pounds of insecticide per acre.

[3] Visual ratings of 0 to 10 with 0 being no crop injury and 10 being complete plant kill.

TABLE V

LATE VISUAL INJURY RATINGS OF ALL TREATMENTS AT PERKINS

		Insecticide																	
		Phorate									Disulfoton								
		Over[1]			With			Side			Over			With			Side		
Herbicide	Rate	0[2]	1	2	0	1	2	0	1	2	0	3/4	1½	0	3/4	1½	0	3/4	1½
Atrazine	0	1[3]	2	4	0	1	4	1	1	1	0	1	1	1	0	1	1	1	1
Atrazine	1	4	3	6	4	6	6	3	4	3	2	4	4	4	5	3	2	2	3
Atrazine	2	6	7	8	5	8	8	6	7	7	7	6	7	5	5	6	5	6	7
Terbutryn	0	1	1	3	1	3	5	1	1	0	1	0	1	0	1	1	1	1	1
Terbutryn	2	5	8	9	3	7	8	5	6	5	5	7	7	2	5	5	4	6	6
Terbutryn	4	9	10	10	8	9	9	8	9	9	9	10	10	6	9	8	9	9	9
Propazine	0	1	1	3	1	2	4	1	1	0	1	1	1	1	0	1	1	1	2
Propazine	2	2	4	5	2	4	6	3	2	2	3	3	3	2	3	4	2	3	3
Propazine	4	4	4	7	4	5	7	4	5	3	4	4	4	3	3	4	3	3	4

1/ Insecticide placement in relation to the seed.

2/ Pounds of insecticide per acre.

3/ Visual ratings of 0 to 10 with 0 being no crop injury and 10 being complete plant kill.

TABLE VI

VISUAL INJURY RATINGS OF ALL
TREATMENTS AT ALVA

		Insecticide																	
		Phorate									Disulfoton								
		Over[1]			With			Side			Over			With			Side		
Herbicide	Rate	0[2]	1	2	0	1	2	0	1	2	0	3/4	1½	0	3/4	1½	0	3/4	1½
Atrazine	0	0[3]	0	2	0	5	8	0	1	0	0	0	0	0	2	3	0	1	0
Atrazine	1	3	1	3	2	5	6	3	1	1	2	2	1	1	4	4	2	2	1
Atrazine	2	3	3	6	3	6	6	2	2	2	5	3	5	3	6	4	2	1	1
Terbutryn	0	2	0	0	1	3	8	1	1	0	0	0	0	1	2	4	0	1	0
Terbutryn	2	3	7	8	2	7	9	1	5	4	1	7	8	3	9	9	1	3	3
Terbutryn	4	6	8	10	4	9	9	4	6	8	6	9	9	4	9	8	3	5	6
Propazine	0	0	0	0	1	4	6	0	0	0	0	1	1	1	4	3	0	0	0
Propazine	2	3	1	2	4	3	5	1	1	1	2	1	2	3	6	7	0	0	0
Propazine	4	2	2	3	2	6	9	2	2	2	3	2	2	3	4	6	2	2	2

1/ Insecticide placement in relation to the seed.

2/ Pounds of insecticide per acre.

3/ Visual ratings of 0 to 10 with 0 being no crop injury and 10 being complete plant kill.

caused significant injury damage ($p<.01$, Tables IV and V).

Terbutryn applied over disulfoton caused significant differences at different levels with the greatest injury occurring at the highest levels of terbutryn and disulfoton (Table VII). Again there were significant differences ($p<.05$) between soil placements with the insecticide placement to the side of the seed causing the least damage at Alva (Table VI). At Perkins the least damage occurred when disulfoton was mixed with the seed (Tables IV and V).

Propazine was also used at the same time as each insecticide. When propazine was used over phorate, there were no interactions of the insecticide levels and herbicide levels. However, at both Alva and Perkins, there were significant differences between insecticide levels, between herbicide levels and between insecticide placements. The greatest injury occurred when phorate was placed with the seed at 2 lbs/A and terbutryn was also present a 4 lbs/A (Tables IV, V and VI). Similar responses were found at Alva when propazine was combined with disulfoton (Table VI). At Perkins the only significant difference when propazine was used with disulfoton was found between levels of propazine; the highest level of propazine caused the most damage to the sorghum (Tables IV and V).

Plant counts were taken from all treatment combinations at Alva and Perkins. Atrazine used with phorate caused no plant stand variations at either Alva or Perkins (Tables VIII and X). However, there were phorate level by phorate placement interactions, in that the least number of plants survived when phorate at 2 lbs/A was placed with the seed at Alva (Table IX). Similar responses were found at Perkins when atrazine was used with phorate (Table X). Atrazine

TABLE VII

SORGHUM INJURY AT ALVA CAUSED BY TERBUTRYN IN CONJUNCTION WITH DISULFOTON

Terbutryn (lbs/A)	Disulfoton[1/]		
	0[2/]	3/4	1½
0	0[3/]	1	1
2	2	6	7
4	5	7	8

[1/]Ratings are averaged over insecticide placements.

[2/]Pounds per acre of disulfoton.

[3/]Visual ratings of 0 to 10 with 0 being no crop injury and 10 being complete plant kill.

TABLE VIII

EFFECTS OF ALL TREATMENT COMBINATIONS ON SORGHUM STANDS AT ALVA

		Insecticide																	
		Phorate									Disulfoton								
		Over[1]			With			Side			Over			With			Side		
Herbicide	Rate	0[2]	1	2	0	1	2	0	1	2	0	3/4	1½	0	3/4	1½	0	3/4	1½
Atrazine	0	21[3]	20	14	21	13	3	17	21	22	22	20	16	21	14	10	17	17	23
Atrazine	1	16	17	9	21	7	9	18	20	16	20	17	12	19	10	10	15	17	16
Atrazine	2	12	8	6	8	4	5	16	16	14	7	9	4	13	8	9	14	18	21
Terbutryn	0	25	24	18	22	11	4	20	19	21	19	21	19	18	17	12	17	18	20
Terbutryn	2	16	5	1	20	5	3	16	13	10	19	6	5	14	2	2	19	13	12
Terbutryn	4	10	3	0	15	1	0	11	4	3	10	2	1	12	1	1	12	9	5
Propazine	0	21	21	19	17	10	9	18	20	21	24	18	22	21	12	12	18	20	20
Propazine	2	13	19	10	17	5	3	16	16	17	17	18	16	19	8	7	18	18	22
Propazine	4	16	18	12	13	7	0	12	15	14	13	13	12	10	6	4	14	13	17

[1] Insecticide placement in relation to the seed.

[2] Pounds of insecticide per acre.

[3] Number of plants occuring in 16 feet of row.

TABLE IX

EFFECTS OF PHORATE AND PHORATE PLACEMENTS
ON STAND VARIATIONS AT ALVA

Phorate (lbs/A)	Insecticide Placement		
	Over	With	Side
0	16*	16	17
1	15	8	19
2	10	6	17

*Number of plants occurring in 16 feet of row when averaged over atrazine treatments.

TABLE X

EFFECTS OF ALL TREATMENT COMBINATIONS ON
SORGHUM STANDS AT PERKINS

		Insecticide																	
		Phorate									Disulfoton								
		Over[1]			With			Side			Over			With			Side		
Herbicide	Rate	0[2]	1	2	0	1	2	0	1	2	0	3/4	1½	0	3/4	1½	0	3/4	1½
Atrazine	0	25[3]	28	21	30	23	15	27	26	28	29	26	31	33	26	25	29	28	26
Atrazine	1	24	26	15	26	14	12	24	23	24	28	26	22	23	19	22	17	26	25
Atrazine	2	16	21	11	25	9	3	23	21	19	19	12	16	25	18	20	21	20	19
Terbutryn	0	26	22	20	30	18	12	26	25	26	33	24	22	29	27	24	25	25	30
Terbutryn	2	18	5	1	21	11	8	20	11	13	21	7	6	19	17	12	22	12	12
Terbutryn	4	3	0	0	8	1	1	2	1	0	1	0	1	11	2	4	2	1	1
Propazine	0	27	29	20	30	20	14	29	24	28	30	25	25	26	25	25	27	26	27
Propazine	2	24	25	16	30	19	9	28	25	26	26	24	23	27	25	18	26	24	27
Propazine	4	25	26	14	29	17	9	27	24	23	25	23	24	26	22	25	25	26	25

[1] Insecticide placement in relation to the seed.

[2] Pounds of insecticide per acre.

[3] Number of plants occurring in 16 feet of row.

used with disulfoton also gave disulfoton by placement interactions at Alva (Table XI). Disulfoton at 1½ lbs/A when placed over the seed resulted in fewer plants than either the check or at 3/4 lbs/A. When disulfoton was placed with the seed at either rate there were fewer plants than when disulfoton was not present. Disulfoton placed to the side of the seed had little effect on plant stands. At Perkins there were no interactions when atrazine was present with disulfoton. However, the rate of atrazine did give significant differences, with the highest rate resulting in the least sorghum plants (Table X).

Terbutryn when in conjunction with phorate did not cause interactions on plant count but phorate level by phorate placement interaction was significant at Alva (Table XII). Fewer plants were present at the highest rate of phorate when it was placed over or with the seed. The least number of plants were present when phorate was placed with the seed at 2 lbs/A. At Perkins there was significant terbutryn level by phorate level interaction (Table XIII). There were fewer sorghum plants with increasing rates of terbutryn or phorate, with the least number of plants found when both phorate and terbutryn were present at their highest rates. When terbutryn was present with disulfoton at Alva there were similar results as with terbutryn and phorate at Perkins (Table VIII). At Perkins, there were no interactions when terbutryn and disulfoton were both present. There were differences caused by levels of terbutryn and disulfoton; with the higher rates causing fewer plants to survive (Table X).

There were no propazine by phorate interactions at either Alva or Perkins. However, again there were significant phorate level by placement differences at Perkins and similar responses on plant

TABLE XI

EFFECTS OF DISULFOTON AND PLACEMENT ON SORGHUM STAND VARIATIONS AT ALVA

Disulfoton (lbs/A)	Insecticide Placement		
	Over	With	Side
0	16*	18	16
3/4	15	10	17
1½	11	10	20

*Number of plants occurring in 16 feet of row when averaged over atrazine treatments.

TABLE XII

EFFECTS OF PHORATE AND PLACEMENT ON SORGHUM STAND VARIATIONS AT ALVA

Phorate (lbs/A)	Insecticide Placement		
	Over	With	Side
0	17*	19	16
1	10	6	12
2	6	2	11

*Number of plants occurring in 16 feet of row when averaged over terbutryn treatments.

TABLE XIII

EFFECTS OF TERBUTRYN AND PHORATE ON SORGHUM STAND AT PERKINS[1/]

Terbutryn (lbs/A)	Phorate 0[2/]	1	2
0	27[3/]	22	19
2	20	9	7
4	4	1	0

[1/]Data are averages of all insecticide placements.

[2/]Pounds per acre of phorate.

[3/]Number of plants occurring in 16 feet of row.

counts at Alva. The least number of plants were present when phorate was placed with the seed at 2 lbs/A (Tables VIII and XIV).

The height of five plants in each plot was measured. Atrazine used with either phorate or disulfoton at both locations did not reduce plant height. The only reduction of plant height was caused by an increase in the rate of atrazine (Tables XV and XVI).

Terbutryn when used with phorate reduced plant height at both Alva and Perkins (Tables XVI and XVII). Herbicide level, and insecticide level increases reduced plant height (Tables XV and XVI). When terbutryn was present with disulfoton, there were no significant interactions; however, the heights of the plants were again reduced by increases in terbutryn levels and disulfoton levels (Tables XV and XVI).

Propazine did not stunt sorghum more so when used with either insecticide than when propazine was used alone at Alva or Perkins. Responses were similar when propazine was present with either insecticide but generally increases in the levels of propazine and the insecticides did stunt the sorghum (Tables XV and XVI).

Head counts made at Alva indicated that atrazine interacted with phorate to reduce the number of sorghum heads, particularly when the highest rate of phorate was placed either with or over the seed (Table XVIII). At Perkins, this interaction did not occur but there were fewer heads when phorate was placed with the seed. The atrazine level when averaged over all other treatments also reduced head production as did the phorate level (Table XIX). Atrazine and disulfoton interacted at Perkins causing reduced head counts when both disulfoton rate and atrazine rates were increased (Table XX). This did not occur at Alva but at both locations an increase in atrazine level

TABLE XIV

EFFECTS OF PHORATE AND PLACEMENTS ON SORGHUM STAND AT PERKINS[1/]

Phorate (lbs/A)	Insecticide Placement		
	Over	With	Side
0	25[2/]	29	28
1	26	19	24
2	16	11	26

[1/]Data are averages of all propazine rates.

[2/]Number of sorghum plants occurring in 16 feet of row.

TABLE XV

EFFECTS OF ALL TREATMENT COMBINATIONS ON
SORGHUM HEIGHT AT ALVA

		Insecticide																	
		Phorate									Disulfoton								
		Over[1]			With			Side			Over			With			Side		
Herbicide	Rate	0[2]	1	2	0	1	2	0	1	2	0	3/4	1½	0	3/4	1½	0	3/4	1½
Atrazine	0	16[3]	22	20	19	19	16	17	18	21	18	13	20	18	15	17	15	19	20
Atrazine	1	9	8	10	13	12	5	12	13	10	9	8	9	12	12	10	13	7	10
Atrazine	2	8	5	11	3	7	4	7	6	9	7	11	6	7	6	5	9	9	11
Terbutryn	0	13	18	17	16	21	18	21	20	24	16	15	20	16	19	18	18	20	22
Terbutryn	2	14	13	7	14	8	8	23	21	19	16	13	13	17	9	6	23	14	18
Terbutryn	4	9	11	3	13	8	4	12	8	13	12	10	16	11	5	3	12	11	8
Propazine	0	13	16	15	15	18	19	18	23	23	14	16	13	16	17	18	18	25	20
Propazine	2	7	9	12	11	6	9	11	14	11	7	9	18	7	7	7	23	11	13
Propazine	4	6	6	7	9	8	1	7	5	10	7	5	7	4	8	9	6	6	5

[1] Insecticide placement in relation to the seed.

[2] Pounds of insecticide per acre.

[3] Height of sorghum plants in centimeters.

TABLE XVI

EFFECTS OF ALL TREATMENTS ON
SORGHUM HEIGHT AT PERKINS

		Insecticide																	
		Phorate									Disulfoton								
		Over[1]			With			Side			Over			With			Side		
Herbicide	Rate	0[2]	1	2	0	1	2	0	1	2	0	3/4	1½	0	3/4	1½	0	3/4	1½
Atrazine	0	33[3]	32	28	29	25	24	29	32	31	32	32	31	27	27	26	31	28	27
Atrazine	1	23	20	17	24	18	16	17	17	18	25	22	21	20	43	21	19	20	20
Atrazine	2	14	11	9	17	13	7	12	13	12	13	12	13	16	15	14	15	13	7
Terbutryn	0	34	33	29	33	31	22	31	31	30	31	31	31	34	32	30	32	29	31
Terbutryn	2	19	15	12	25	20	14	24	17	17	21	21	19	28	19	18	22	18	17
Terbutryn	4	12	0	0	16	4	8	15	4	13	8	4	8	15	13	9	8	9	3
Propazine	0	31	31	27	32	30	24	32	30	35	30	31	29	30	31	31	32	31	31
Propazine	2	20	18	16	24	20	12	25	22	20	21	23	21	22	22	19	24	24	20
Propazine	4	22	23	16	21	21	19	18	17	16	25	24	25	26	25	26	19	18	21

[1] Insecticide placement in relation to seed.

[2] Pounds of insecticide per acre.

[3] Height of sorghum plants in centimeters.

TABLE XVII

EFFECTS OF TERBUTRYN AND PHORATE ON PLANT HEIGHT AT ALVA

Terbutryn (lbs/A)	Phorate 0[1]	1	2
0	17[2]	20	20
2	17	14	11
4	11	9	7

[1] Rates of phorate expressed in lbs/A.

[2] Height of sorghum plants in centimeters when averaged over insecticide placements.

TABLE XVIII

EFFECTS OF ALL TREATMENTS ON SORGHUM HEAD COUNTS AT ALVA

		Insecticide																	
		Phorate									Disulfoton								
		Over[1]			With			Side			Over			With			Side		
Herbicide	Rate	0[2]	1	2	0	1	2	0	1	2	0	3/4	1½	0	3/4	1½	0	3/4	1½
Atrazine	0	53[3]	54	45	52	35	64	41	51	64	55	57	52	51	36	32	42	51	47
Atrazine	1	46	37	28	55	20	23	46	53	45	37	48	27	47	33	26	45	36	46
Atrazine	2	23	16	12	19	16	9	33	38	33	14	33	12	29	19	22	31	42	43
Terbutryn	0	63	62	44	46	24	9	36	52	68	52	54	56	48	34	32	42	49	49
Terbutryn	2	52	31	15	55	21	15	54	42	40	51	35	31	54	10	22	55	43	42
Terbutryn	4	48	22	6	53	6	1	47	25	9	49	11	7	50	12	8	50	45	20
Propazine	0	56	57	49	49	29	6	42	50	60	62	54	51	49	35	32	44	53	45
Propazine	2	35	42	26	36	20	13	46	43	46	33	43	43	54	18	19	42	48	59
Propazine	4	34	34	28	34	17	1	18	34	30	43	26	32	24	21	11	35	28	36

[1] Insecticide placement in relation to the seed.

[2] Pounds of insecticide per acre.

[3] Number of sorghum heads produced in 16 feet of row.

TABLE XIX

EFFECTS OF ALL TREATMENTS ON SORGHUM HEAD COUNTS AT PERKINS

		Insecticide																	
		Phorate									Disulfoton								
		Over[1]			With			Side			Over			With			Side		
Herbicide	Rate	0[2]	1	2	0	1	2	0	1	2	0	3/4	1½	0	3/4	1½	0	3/4	1½
Atrazine	0	64[3]	51	44	65	44	31	59	56	72	70	60	72	65	68	67	72	64	59
Atrazine	1	57	54	30	61	42	33	50	37	62	61	62	52	58	63	61	58	59	48
Atrazine	2	49	35	25	54	28	14	40	32	38	39	42	33	51	54	43	54	51	27
Terbutryn	0	71	52	42	74	57	50	71	51	68	65	66	66	71	80	65	70	70	62
Terbutryn	2	50	20	8	54	22	11	48	32	36	53	26	29	57	45	39	68	39	37
Terbutryn	4	14	0	0	23	4	0	8	3	2	8	1	2	33	11	13	10	9	3
Propazine	0	71	60	38	64	48	31	70	57	79	60	71	57	60	57	58	69	74	63
Propazine	2	66	54	34	74	47	23	62	50	67	60	60	53	62	60	55	71	67	53
Propazine	4	60	49	23	60	38	27	50	41	53	51	64	48	59	62	58	57	67	53

[1] Insecticide placement in relation to the seed.

[2] Pounds of insecticides per acre.

[3] Averages of the number of sorghum heads occurring in 8 feet of row.

TABLE XX

EFFECT OF DISULFOTON AND ATRAZINE ON SORGHUM HEAD COUNTS AT PERKINS

Atrazine (lbs/A)	Disulfoton		
	0[1/]	3/4	1½
0	69[2/]	64	66
1	59	61	53
2	48	49	34

[1/] Rates of disulfoton expressed in lbs/A.

[2/] Averages of the number of sorghum heads produced in 8 feet of row when averaged over the insecticide placements.

reduced the sorghum heads (Tables XVIII and XIX).

At Alva terbutryn used with phorate caused reductions in the number of sorghum heads. There were the fewest sorghum heads when terbutryn and phorate were both used at their highest rates and the phorate was placed with the sorghum seeds (Table XVIII). Significant head count reductions were obtained from each factor; i.e. terbutryn level, phorate level, and phorate placement. At Perkins, the interactions did not occur but again there were significant head reductions when the terbutryn or insecticide levels were increased (Table XIX) at both locations. When terbutryn and disulfoton were both present at Alva, the least number of sorghum heads occurred when both were used at their highest rates (Tables XIX and XXI).

Propazine when used with phorate did not influence head count. However, phorate placed with the seed resulted in the least number of sorghum heads (Tables XVIII and XIX). Propazine, disulfoton treatment rate and disulfoton placement interacted and significantly reduced the sorghum head count at Alva. This was not ture at Perkins, however, the propazine and disulfoton did interact resulting in less sorghum heads with increasing rates of propazine and disulfoton (Tables XVIII and XIX).

Sorghum head length was taken at Perkins for all treatment combinations. Atrazine did not affect head length when used with either phorate or disulfoton. However, the placement of phorate with the seed did increase the length of the sorghum heads. This is probably due to the reduced stand which allowed for better growth and production of the few remaining plants. All other combinations of both insecticides with terbutryn and propazine either resulted in

TABLE XXI

EFFECT OF DISULFOTON AND TERBUTRYN ON
SORGHUM HEAD COUNTS AT ALVA

Terbutryn (lbs/A)	Disulfoton		
	0[1]	3/4	1½
0	47[2]	46	46
2	53	29	31
4	49	22	11

[1] Rate of disulfoton expressed as lbs/A.

[2] Number of sorghum heads produced in 16 feet of row when averaged over insecticide placements.

no significant interactions or the significant ones seemed to result from a reduction of the number of sorghum heads in the plots (Table XXII).

Grain was harvested at Alva, but due to severe bird damage the yield variations were partially masked. The placement of phorate with the seed when atrazine or terbutryn was present gave the least yield (Table XXIII). Averaged over all treatments, higher insecticide levels resulted in lower grain yields (Table XXIV). When atrazine was used with disulfoton, the placement of disulfoton over the seed resulted in the least grain yield. Highest yields were obtained when disulfoton was placed 1½ inches to the side of the seed (Table XXV). No interaction was observed between terbutryn and disulfoton. Propazine combined with phorate caused reduced yields at all placement combinations. The higher the rate of phorate, the lower the yield when the phorate was placed with the seed. The rate of propazine also affected the yield with decreasing yields resulting from increasing rates of the herbicide (Table XXIV). The propazine rates also affected the yield similarly when combined with disulfoton. Also the placement of disulfoton with the sorghum seed reduced the yield most among the insecticide placements (Table XXV).

In general, field studies indicated that there was greater phytotoxicity and pesticide interaction when terbutryn was used than atrazine or propazine. Injury was greater when both herbicides and insecticides were used on the sorghum. This increased injury could result from an inhibition of the hydrolysis of the herbicide by the insecticide or by an increase in the uptake of the herbicides when the insecticide is present. Matsunaka (24) reported that

TABLE XXII

EFFECTS OF ALL TREATMENTS ON SORGHUM
HEAD LENGTH AT PERKINS

		Insecticide																	
		Phorate									Disulfoton								
		Over[1]			With			Side			Over			With			Side		
Herbicide	Rate	0[2]	1	2	0	1	2	0	1	2	0	3/4	1½	0	3/4	1½	0	3/4	1½
Atrazine	0	18[3]	17	18	17	18	19	17	17	18	17	17	17	17	17	18	17	16	18
Atrazine	1	18	18	18	17	20	18	18	18	18	18	17	18	18	19	17	18	18	19
Atrazine	2	18	16	20	19	21	21	18	19	19	18	19	19	18	18	19	18	18	19
Terbutryn	0	17	17	17	18	18	18	18	17	17	18	18	18	16	18	17	17	18	16
Terbutryn	2	18	20	20	17	20	20	19	20	19	18	20	18	18	19	19	18	19	19
Terbutryn	4	21	0	0	20	14	6	14	6	14	13	8	14	19	20	20	14	15	7
Propazine	0	17	18	18	17	19	19	17	17	17	18	18	18	17	17	17	17	18	17
Propazine	2	18	18	18	18	19	21	18	18	18	17	18	19	18	18	18	17	19	17
Propazine	4	17	19	19	17	20	21	18	18	18	19	18	17	18	19	18	18	19	18

[1] Insecticide placement in relation to the seed.

[2] Pounds of insecticide per acre.

[3] Average length in centimeters of five sorghum heads taken at random from the treated area.

TABLE XXIII

EFFECTS ON GRAIN YIELD BY PHORATE AT ALL INSECTICIDE PLACEMENTS AT ALVA

Phorate (lbs/A)	Insecticide Placement		
	Over	With	Side
0	630*	980	780
1	640	680	880
2	510	290	910

*Grain yield in grams for 16 feet of row when averaged over atrazine rates.

TABLE XXIV

EFFECT ON YIELD AT ALVA OF PHORATE AT ALL
PLACEMENTS WITH ALL HERBICIDES

		Phorate								
		Over[1]			With			Side		
Herbicide	Rate	0[2]	1	2	0	1	2	0	1	2
Atrazine	0	865[3]	936	941	1338	936	139	650	666	1208
Atrazine	1	802	787	485	1039	840	597	842	956	820
Atrazine	2	229	178	112	578	281	127	860	1000	692
Terbutryn	0	1040	1147	1039	900	722	155	509	639	1257
Terbutryn	2	1409	1036	629	1098	533	471	1249	976	1223
Terbutryn	4	1571	967	219	1566	196	72	1284	584	316
Propazine	0	1137	1259	1301	1059	829	147	690	692	1159
Propazine	2	648	492	579	536	523	321	902	1061	1105
Propazine	4	884	889	897	428	301	19	306	741	436

[1] Insecticide placement in relation to the seed.

[2] Pounds of insecticide per acre.

[3] Grain yield in grams for 16 feet of row.

TABLE XXV

EFFECT ON YIELD OF DISULFOTON AT ALL PLACEMENTS WITH ALL HERBICIDES

Herbicide	Rate	Disulfoton								
		Over[1]			With			Side		
		0[2]	3/4	1½	0	3/4	1½	0	3/4	1½
Atrazine	0	859[3]	1017	604	1053	1187	1215	650	1159	975
Atrazine	1	752	743	549	795	612	667	929	908	887
Atrazine	2	199	196	77	473	293	462	1061	1061	1185
Terbutryn	0	955	1054	950	945	941	1342	690	1021	804
Terbutryn	2	1364	1385	1383	1159	327	531	750	1067	1158
Terbutryn	4	1456	443	291	1717	333	256	1410	1249	693
Propazine	0	1243	1037	738	1059	1064	1279	711	1297	1146
Propazine	2	639	499	329	854	239	442	1042	1527	1001
Propazine	4	1072	672	647	301	314	145	804	617	689

[1] Insecticide placement in relation to the seed.

[2] Pounds of insecticide per acre.

[3] Grain yield in grams for 16 feet of row.

propanil hydrolysis by rice plants is inhibited by insecticides. He concluded that the injury to rice plants by insecticides sprayed on them with propanil seemed to be caused by the inhibition of the propanil detoxifying enzyme. Hamill and Penner (11) indicated that carbofuran interacted synergistically with alachlor to reduce barley seedling growth and appeared to be caused by greater alachlor uptake by plants which had received the carbofuran seed treatment.

The placement of the insecticide in relation to the seed caused variation in sorghum injury. When the insecticide was placed with the seed there was more injury than when it was placed over the seed or to the side of the seed. The least crop injury was observed when the insecticide was placed to the side of the seed. These differences probably can be explained by the closeness of the insecticide to the point of uptake by the plant roots.

CHAPTER V

SUMMARY

Field studies were conducted to compare the phytotoxicity to sorghum of atrazine at 1, and 2 lbs/A, and of propazine and terbutryn at 2, and 4 lbs/A used in conjunction with the insecticides phorate at 1, and 2 lbs/A and disulfoton at 3/4, and 1½ lbs/A. Insecticides were applied at the time of planting either as a 7 inch band over the seed on the surface of the soil, an in-furrow mixture with the seed, or as a one inch band placed 1½ inches to the side at the same depth as the seed. The herbicides were applied as preemergence treatments on the soil surface.

Terbutryn caused more interaction with the two insecticides than did atrazine or propazine. Propazine interacted slightly less than atrazine. More injurious effects were observed with phorate than with disulfoton when either were used in conjunction with the herbicides. Injury was increased with increasing rates of the herbicides and insecticides with the most injury occurring when the herbicide and insecticide were present at their highest rate. In general the insecticide placement influenced the pesticide interactions. More injury occurred to the sorghum when the insecticide was mixed with the seed, with or without herbicide presence. The least injury occurred when the insecticide was placed 1½ inches to the side of the seed.

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