A STUDY OF PLANTING TIME APPLICATIONS FOR GREENBUG CONTROL ON GRAIN SORGHUM

by 1050 710

HARLAN DEAN FEESE

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Approved by:

[signature]
Major Professor

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INTRODUCTION

The greenbug, *Schizaphis graminum* (Rondani), has been an economically important pest on grain sorghum in the United States since 1968. Growers have relied mainly on chemical control measures to reduce its populations and prevent economic damage. More recently the utilization of integrated control programs has proven effective by the use of predators and selected chemicals as control combinations. The use of planting time treatments has also become popular because of its convenience and the likelihood of seedling infestations, especially in Eastern Kansas.

Some growers in Central Kansas have observed what they believe to be substantial greenbug buildup on young, just emerged grain sorghum even though a recommended systemic granular insecticide was applied at planting time. Large greenbug flights coincided with emergence of the sorghum in that area; therefore, greenbug populations were present when sorghum plants began emerging and immediately infested the seedlings. How soon sorghum plants pick up the insecticide and whether this occurs before any damage results is not well known.

The effect of foliar insecticide applications on predators is relatively well known; however, little information is available regarding the effects of granular systemic insecticides on predators. Manufacturers of systemic insecticides are quick to argue that their products have no affect on predators; however, this is not the consensus of many entomologists.

With the presence of relatively high greenbug populations on seedling sorghum, the question arose as to the affect these high populations would have on yields, even though the infestations may be suppressed or eliminated by chemicals and/or natural control agents.

Mixtures of insecticides and herbicides are becoming increasingly important in crop production. Whether the chemicals are applied as mixtures or used singly, it is reasonable to expect that more than one pesticide will be in association within the plant simultaneously. Individual pesticides, when applied correctly, usually perform satisfactorily. Considerable research has been performed on phytotoxic reactions resulting from herbicides used in conjunction with insecticides. Another aspect, to which little attention has been devoted, is how the herbicide affects the toxicity of the insecticide. The possibility might exist that certain herbicides, when used in conjunction with certain insecticides, could result in an antagonistic or synergistic effect on the insecticide.

The purpose of this study was to investigate the affect of placement and formulation of selected insecticides on the initial and residual control of greenbugs on seedlings and older grain sorghum plants. At the same time other areas related to the use of planting time systemic granular insecticides were investigated. These included determining the effects of 1) systemic granular insecticides on greenbug predators, 2) seedling infestations of greenbugs on sorghum yields, and 3) selected herbicides on granular systemic insecticides with regard to possible synergistic or antagonistic results in controlling greenbugs.

REVIEW OF LITERATURE

The greenbug, *Schizaphis graminum*, was first described in Italy in 1852 by Rondani. The first recorded observation of the greenbug in the United States was on oats and wheat near Culpeper, Virginia, in 1882 (Webster and Phillips, 1912). Major outbreaks have occurred spasmodically. Daniels et al. (1956) noted that early outbreaks were confined to small areas, generally five to six counties and mainly in the Texas Panhandle, Oklahoma, and Southwestern and Southcentral Kansas. The first major and extensive outbreak of greenbugs occurred in 1906-1907 (Webster and Phillips, 1912). It began in Central Texas and swept northward and eastward through Oklahoma, Kansas, Arkansas, Missouri, and across Illinois to within 60 miles of Chicago. By the end of the growing season, infestations had spread west to Colorado and as far east as Washington, D. C. From a geographical standpoint, this was the greatest infestation known. The 1906-1907 outbreak was the first recorded appearance of greenbugs in Kansas (Hunter, 1909).

In 1968 grain sorghum over extensive areas of the United States was seriously damaged by greenbugs for the first time. Greenbug outbreaks on sorghum were reported from Arizona, Colorado, Kansas, Nebraska, Oklahoma, South Dakota, and Texas (USDA, 1968). The 1968 outbreak made greenbugs a threat to two major Great Plains crops, wheat and grain sorghum. The growing season for these overlapping crops could provide an abundance of favorable host plants throughout the year (Harvey and Hackerott, 1969).

Relatively little work has been done on the initial effectiveness of systemic insecticides with regard to just emerged grain sorghum seedlings. DePew et al. (1970) noted that granular disulfoton and granular carbofuran gave 100% control of greenbugs on grain sorghum 30 days after planting. Greenbugs were not present prior to the first count; therefore, it is difficult to state that an effective control would have resulted when the seedlings first emerged. In a greenhouse experiment, they demonstrated that phorate (1 lb/acre) applied at planting time gave 100% control of chinch bugs and greenbugs on grain sorghum seedlings 15 days after planting. Disulfoton at the same rate applied at planting gave equally good control of greenbugs but only 20% control of chinch bugs (Wilde and Boling, 1972). Daniels (1970) indicated that a band application of 15G disulfoton (1 lb/acre) controlled greenbug infestations occurring 41 days later. Cate et al. (1973b) noted that side-dress treatments of granular or liquid disulfoton were effective against greenbugs, but a period of 2-3 weeks after application was required for best control

Lack of soil moisture can be a vital factor in influencing performance of granular soil systemics. Because moisture is needed to activate these compounds, effective results may not be achieved in non-irrigated areas during a dry year (DePew, 1971). Certain insecticides of low water-solubility took as much as 2 weeks or longer to attain aphid mortalities obtained in a few days with moderately water-soluble chemicals (Reynolds and Metcalf, 1962). In a test involving lygus bug control on cotton, Ridgway et al. (1966) observed that control from the soil treatment with UC-21149 was somewhat delayed. However, the cotton was not irrigated until 13-14 days after application of the insecticide. Lygus bug control with the soil treatment increased considerably 11-18 days after the UC-21149 was applied.

Natural populations of predators and parasites are important in regulating pest populations. There are certain insects which subsist largely upon the greenbug, devouring it in great numbers (Hunter, 1909). Interest is steadily increasing in the development of programs which make compatible use of chemical and biological methods of controlling pests. The initial step in the development of such a program is to obtain evidence that differential toxicity responses to an insecticide favors the natural enemies of the pest (Hamilton and Kieckhefer, 1969).

Considerable research has been done on greenbug predators. Ward et al. (1970) stated, in general, the more effective the insecticide was in controlling the greenbug, the greater its suppressive effect on beneficial insect populations. Ridgway et al. (1967) observed increased numbers of eggs and larvae of *Heliothis* spp. as the population of predators decreased following the application of selected systemic insecticides on cotton. Reduced numbers of parasites and predators in plots treated with the more effective insecticides against greenbugs could result from the direct toxic effects of the insecticides on the beneficial species, emigration of predators and parasites from the plots following elimination of the host, or the parasites and predators could act as density dependent factors and the plots with greater greenbug densities favor greater densities of natural enemies (Cate et al., 1973b). Different predator/parasite species are affected in different ways.

Ahmed et al. (1954) reported that larvae of three species of Syrphidae were readily killed when fed aphids which had fed on leaves treated with systemic insecticides. However, when similar aphids were fed to Coccinellidae and *Chrysopa* spp. larvae, mortality rates were 3.7-100% or only 2%, respectively. Some species are thought to feed directly on the plant and might be affected by systemic insecticides present in the plant. At least two predators, *Geocoris* spp. and *Nabis* spp., feed on plants to obtain moisture (York, 1944). Timmons et al. (1973) demonstrated the detrimental effects of aldicarb to predators. Pretreatment samples showed a much higher number of predators in the aldicarb treated fields than in the untreated fields. Posttreatment samples showed that predator populations had been drastically reduced in the aldicarb treated fields, yet a slight increase was noted in the untreated fields. This indicated the plant had been taking up the aldicarb and was reducing the predator population by passing the toxicant through the food chain, by volitization, or by some other mechanism.

Numerous studies have been conducted to determine effects of greenbug infestations on yield. Teetes and Johnson (1973) noted significant grain losses resulting from a mean of ca. 1300-1500 greenbugs per plant at about the bloom stage of growth or a mean leaf death in excess of three per plant.

Studies suggest, if two or more mature leaves are destroyed on grain sorghum plants prior to or during the milk to early dough stage, grain yields will be lowered (Daniels and Chedester, 1972). Harvey and Hackerott (1970) reported losses in grain production in untreated vs. treated plots of from 2% (1.4 bu/acre) to 45% (27.0 bu/acre) depending on time and intensity of greenbug infestation. According to Daniels (1971), small plants (5 inches tall) which receive no treatment died within 4 days after the population reached 2,700 greenbugs per plant. Plants 19 inches tall with no insecticide treatment died within 14 days after a population peak of 13,500 greenbugs per plant. Almand et al. (1969) suggested guidelines for treatment of greenbug infestations. Plants from emergence to 6 inches high should be treated when there is visible damage with colonies of greenbugs on lower leaf surface; larger plants to preboot stage should be treated when greenbug numbers are sufficient to cause death of more than the two lower normal sized leaves.

Chemical control of relatively light infestations of greenbugs would not significantly increase production of grain sorghum (Cate et al., 1973a). Little information is available on greenbug infestations and their effects on yield when present in large numbers on seedling sorghum. In resistance studies, plant height of both resistant and susceptible sorghum varieties was reduced by greenbug infestations although plant height did not differ at maturity. Greenbug infestations on seedling plants also delayed maturity of both resistant and susceptible varieties and reduced the yields of susceptible varieties (Harvey and Hackerott, 1974).

Research has been performed to determine the effect of pesticide combinations to the plant. The synergistic interaction of certain pesticide combinations in some instances may be due to inhibition by the insecticides of metabolic processes in the plant that are active in degradation of the herbicide (Swanson and Swanson, 1968). However, the effects of pesticide combinations with respect to decreased toxicity of the insecticide to the insect pest have not been investigated. Deleterious interactions which might result from pesticide combinations are increased phytotoxicity to desirable plant species, increased residual life of chemicals in the soil, or inactivation of the pesticide (Wedderburn, 1970).

In tests involving selected fungicides/insecticides/herbicide combinations on cotton, Chambers et al. (1968) noted significant differences in emergence, seedling mortality, survival, disease injury, and seedling vigor but no significant differences in insect injury were observed. Early season insect control appeared to be affected very little by combinations of pesticides. Combinations containing insecticides gave excellent early season insect control (Chambers et al., 1969).

MATERIALS AND METHODS

DeKalb E59 grain sorghum was planted at the East Central Experiment Station near Ottowa, Kansas, in 30 inch rows at a rate of 4 pounds of seed per acre on June 12, 1973. Treatments consisted of four 100-foot rows replicated three times in complete randomized blocks. In each treatment four rows were treated with a preemergence herbicide broadcast in 20 gallons of water at recommended rates; in addition, the two outside rows were treated with recommended rates of granular disulfoton, phorate, or carbofuran with a Gandy RoWheel Applicator. Plant samples were taken 15 and 34 days after planting.

Similar tests were conducted at the Ashland Agronomy Farm Unit 1 near Ashland, Kansas. The design of the experiment was the same as the Ottowa tests; however, insecticide/herbicide combinations differed. One treatment received insecticide application as usual but received postemergence applications of herbicides.

The effect of granular systemic insecticide placement and selected seed treatments on greenbug populations was studied at the Rocky Ford Agronomy Farm near Manhattan, Kansas. Three varieties of grain sorghum were used. T-E-Y-101 was commercially treated with DS 15647 at 4, 6, and 8 ounces (active chemical/100 lb seed). Pioneer 8442 was commercially treated with Orthene at 2, 4, 8, and 16 ounces (active chemical/100 lb seed). Furrow and band applications of granular systemic insecticides were applied to RS-701 grain sorghum. Plots were planted May 18, 1973, in 30-inch rows, 25 feet long, and 3 inches deep with a hand operated cone seeder. Furrow treatments were made by evenly distributing the premeasured granular systemic insecticide over the seed on the cone seeder. Band treatments were made by distributing the premeasured granules on top of the ground directly above the planted seed with a test tube to evenly distribute the chemical. Originally 22 rows of sorghum were planted with a control for each variety; however, the control for RS-701 was accidentally treated and was not sampled. Plant samples were taken 7, 25, 53, and 60 days after planting. Tests conducted at Ottowa, Ashland, and Manhattan were on dry land plots.

A lab test was conducted using the DS 15647 and Orthene seed treatments. Seeds were planted in clay pots 5 inches in diameter and filled 3/4 full of soil. Pots were then watered and placed outside the lab. Plant samples were taken 9, 21, and 35 days after planting.

Plant samples for the preceding tests were taken as follows. Twenty-five ml glass vials with screw-on lids were filled with white silica sand moistened with 5 ml of tap water. On initial samplings the entire plant was used with the exception of the Ashland and Ottowa tests. Plants were selected at random, cut with scissors at the soil line, and pushed with forceps into the sand contained in the vial. On subsequent samplings as well as samples taken initially at Ashland and Ottowa, leaf sections were obtained by randomly selecting leaves, cutting a section ca. 4-5 cm in length, and pushing the leaf into the sand contained in the vial. Four random samples were taken from each replicate. Plant samples were brought to the lab where the vial lids were removed; and, with a fine camels hair brush, three apterous greenbugs were placed on each sample. Lids were replaced on the vials after infesting the leaf area. Vials were placed on trays in growth chambers for 48 hours at a temperature of 83° F. After 48 hours samples were removed from the growth chambers and the number of live greenbugs were recorded. Preliminary studies indicated this was an effective method for evaluating the efficacy of systemic insecticides.

RS-701 grain sorghum was planted in clay pots 5 inches in diameter, approximately 20 seeds per pot. Ten pots were planted prior to each test. Five pots were treated by sprinkling 40 mg of 15G disulfoton (equivalent to 1 lb AI/acre) over the surface of the soil with a test tube; the remaining five pots served as controls. Pots were then watered and maintained as needed until testing time. Predators, *Orius insidiosus* (Say) (Anthocoridae), *Hippodamia convergens* Guerin-Meneville (Coccinellidae), *Chrysopa* sp. (Chrysopidae), and *Nabis* sp. (Nabidae), were collected in the morning prior to the beginning of a test by sweeping the foliage of alfalfa with a 15-inch sweep net, placed individually in 25 ml glass vials with screw top lids, and returned to the laboratory as quickly as possible. Predator cages (Ohiagu, 1973) were constructed of two glass vials, an upper vial 8 inches long with a 1-inch diameter and open on both ends and a lower vial 3½ inches long with a 1-inch diameter and open on one end only (Plate 1). Lower vials, containing water, were capped with plastic tops having the centers removed. A foam plastic sponge, partially split longitudinally, was fitted through this hole and served to hold the sorghum plant in position with the roots submerged in the water. Seedlings were removed from the clay pots. Removing as much soil as possible, the root portions were placed individually in the lower vials as described above. The upper vial, with four windows

EXPLANATION OF PLATE 1

Cages used to confine greenbug predators
on single sorghum plants

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PLATE 1

in its wall covered with fine mesh nylon screen, enclosed the above ground portion of the seedling. Tests consisted of 24 observations of 12 treated and 12 untreated plants. With a fine camels hair brush, 20 apterous greenbugs were placed on each of six treated and six untreated plants. Greenbugs were not placed on the remaining treated and untreated plants. The remaining open end of the upper vial was closed with a plug fashioned from foam rubber to prevent greenbugs or predators from escaping. Predators were introduced 2 hours after the greenbugs and their progress was recorded daily. In cages containing greenbugs, the population was maintained at approximately 20 greenbugs per plant by reinfesting as needed. In tests with larger predators, *Nabis* sp. and *H. convergens*, the predators were removed each time greenbugs were reintroduced so as to allow the new greenbugs to establish themselves. In tests involving small predators, *Chrysopa* sp. and *O. insidiosus*, the predators remained in the cages as new greenbugs were reintroduced. The tests were terminated after 4 days.

A greenbug survey on June 8, 1973, disclosed a field in Marion County, Kansas, which had an unusually large greenbug population on 4-6 inch grain sorghum. After personal communication with the grower, it was noted that the field had been planted May 1, 1973, with Pioneer 846 grain sorghum in 36-inch rows. Pretreatment counts of greenbugs and predators were made. Five rows, 100 feet long were treated with 14.4 gm of 15G disulfoton (equivalent of 1.0 lb AI/acre) by broadcasting the insecticide with a test tube. On June 13, 1973, counts were taken from disulfoton treated and untreated rows. Except for the disulfoton treated rows and ten rows on the east side of the field, the field was then sprayed with dimethoate (1 lb/acre) by the grower. On June 19, 1973, counts were made on all treatments. When counts were made, the number of greenbugs, number and type of predators, apparent greenbug damage, and plant stage were recorded by the method described by Vanderlip (1972). On September 14, 1973, seed yields were obtained by hand harvesting four 50-foot sections, randomly selected from each treatment. Samples were mechanically threshed, cleaned, weighed, and the data converted to pounds per acre at 15.5% moisture content.

On June 9, 1973, the county agent in Saline County informed our office of three growers who were becoming concerned with the greenbug buildup on their seedling sorghum. Planting time applications apparently were having little or no effect on the greenbug population. After personal communication with the growers, it was noted that all three had applied 15% disulfoton granules at recommended rates (1 lb/acre) in 36-inch rows. Additional pertinent information is presented in Table 1. Surveys were conducted in each field on June 11, 13, and 19, 1973. In each survey the following observations were made: 1) plant height, 2) plant growth stage, 3) number of predators, 4) number of parasitized aphids, 5) number of alate and apterous aphids per plant, and 6) aphid damage. Also leaf sections were obtained randomly from ten plants in each field and handled in the same manner as samples taken at Rocky Ford, Ashland, and Ottowa. Untreated leaf sections were obtained from untreated RS-701 sorghum grown in the laboratory. Samples were infested and handled as previously described.

Table 1. Field history of three fields surveyed in Saline County, Kansas. 1973.

Field number	Planting date	Grain sorghum variety	Mean number of plants /50-ft row	Rainfall between planting date and first sampling
1	May 29	Asgrow	151.5	0.68
2	May 31	Excell	187.5	1.10
3	May 26	Asgrow Double Tx	147.5	0.65

RESULTS AND DISCUSSION

Table 2 depicts the results of the placement and formulation study of granular systemic insecticides conducted at Rocky Ford Agronomy Farm. At the first sampling date all compounds appeared to be actively present and affecting greenbugs with the exception of the band application of SN 316. At 26 days the compounds still appeared to be active; however, the mean number of live greenbugs were for the most part less than had occurred at the 7-day sampling. Although the means were not significantly different, a trend appears to indicate that compounds might not be present in younger plants at the concentrations present in older plants. Little difference can be noted with regard to placement at the 26-day sampling except that the furrow treatment of SN 316 appeared less effective. At 53 days only three furrow treatments, disulfoton, phorate, and carbofuran, were sampled. All three compounds appeared to be less effective than at the 26-day sampling, although disulfoton appeared to be providing adequate control. At the 60-day sampling all compounds were losing their effectiveness with the exception of furrow treatments of DS 15647 at both the .5 and 1 pound/acre rates. All compounds provided some greenbug control. There was no significant difference between furrow and band placements according to Duncan's Multiple Range Test at the 5% level. Cate el al. (1973b) reported effective control from both sidedress and furrow treatments of disulfoton; however, the sidedress treatments required ca. 2-3 weeks after application for best control.

Table 2. Bioassay of selected insecticide rates and placement based on the ability of apterous greenbugs to survive and reproduce for 48 hours on plant samples obtained 7, 26, 53, and 60 days after planting. Rocky Ford Agronomy Farm, Manhattan, Kansas. 1973.

Insecticide	Rate	Placement	Mean no. of live greenbugs				% Germination
			7 days	26 days	53 days	60 days	
Disulfoton	1 lb AI/acre	Furrow	1.25	0	2.0	6.75	64
Disulfoton	1 lb AI/acre	Band	0	0	-	4.50	73
Phorate	1 lb AI/acre	Furrow	3.50	1.75	5.2	8.75	63
Phorate	1 lb AI/acre	Band	0.25	0	-	8.00	57
Carbofuran	1 lb AI/acre	Furrow	0	0	8.8	7.00	83
Carbofuran	1 lb AI/acre	Band	1.00	1.50	-	11.75	71
DS 15647	1 lb AI/acre	Furrow	0	0.75	-	1.75	61
DS 15647	1 lb AI/acre	Band	0	0	-	3.75	59
DS 15647	.5 lb AI/acre	Furrow	0	2.00	-	1.75	65
DS 15647	.5 lb AI/acre	Band	1.00	0.75	-	8.00	66
SN 316	.75 lb AI/acre	Furrow	2.50	4.75	-	9.00	50
SN 316	.75 lb AI/acre	Band	5.75	5.25	-	9.75	67
Untreated			6.50	9.00	-	14.25	73

The results of the seed treatment tests are presented in Table 3. In the field tests the performance of DS 15647 was excellent at all concentrations at the 7-day sampling and Orthene at the 16-ounce concentration performed equally well. At the 26-day sampling, DS 15647 appeared to be less effective than at the earlier sampling while Orthene treatments remained relatively unchanged except for the 8-ounce and 16-ounce concentrations. The higher means at the 26-day sampling indicate that the Orthene concentration is being reduced by some factor. In some instances the lower concentrations appeared to provide better greenbug control than the higher concentrations. This is particularily apparent at the 26-day sampling of Orthene treatments. The 2-ounce concentration of Orthene provided the best control while the 16-ounce concentration of the same compound was lesser effective. The reason for this phenomenon is not known. Bottrell and Cate (1970) obtained similar results while testing the effectiveness of Azodrin as a seed treatment. Eight-ounce concentrations of Azodrin were less effective than 4-ounce concentrations.

At the 60-day sampling all seed treatments appeared to be losing their effectiveness. In the lab tests involving seed treatments with the same compounds and concentrations, DS 15647 gave excellent greenbug control at all concentrations and on all 3 sampling days. However, germination was severely affected, especially by the heaviest concentration. Overall, the Orthene lab treatments gave control comparable to the Orthene field tests; however, there was a greater reduction in seed germination under laboratory conditions than in the field. The reasons for reduced germination in the lab test are not known although it might be due to the high concentration of seeds in a small container.

Table 3. Bioassay of two seed treatments based on the ability of apterous greenbugs to survive and reproduce for 48 hours on plant samples obtained at a given number of days after planting. Manhattan, Kansas. 1973.

Chemical[a]	oz AI/ 100 lbs seed	Mean no. of live greenbugs							
		Field Test[b]				Lab Test[c]			
		7 days	26 days	60 days	% germination	9 days	21 days	35 days	% germination
Orthene	2	2.8	2.3	10.3	65	2.5	1.3	3.8	56
Orthene	4	4.8	3.8	11.5	63	0.3	0.5	3.8	60
Orthene	8	1.5	5.5	10.3	60	0	2.8	5.8	52
Orthene	16	0	8.0	7.3	64	0	1.5	2.0	46
Untreated		6.5	9.0	14.3	73	5.5	4.3	4.5	58
DS 15647	4	0	7.3	8.5	65	0	0	0	36
DS 15647	6	0	2.5	8.8	64	0	0	0	36
DS 15647	8	0	3.5	10.3	67	0	0	0	16
Untreated		7.0	6.3	8.3	51	2.5	4.0	5.5	54

[a]Two different seed varieties used; Orthene - Pioneer 8442, DS 15647 - T-E-Y-101.

[b]Samples taken from plants at Rocky Ford Agronomy Farm.

[c]Samples taken from plants reared in laboratory.

Results of the survey conducted in Saline County are presented in Figure 1. Suppression of greenbugs in Field 1 began ca. 16 days after planting; by 22 days after planting, the greenbug population had been eliminated. Peak infestation in Field 2 was ca. 14 days after planting and began declining rapidly. Field 3 had its peak greenbug infestation ca. 19 days after planting; however, the populations had been virtually eliminated by the 25th day after planting.

Results of leaf samples taken on each survey date are summarized in Table 4. Tests conducted with leaf samples in the lab support observations of the surveys. Field 1 and 2 showed increases in the number of live aphids after 48 hours on the June 11 and 13 samples. After June 13 the presence of the insecticide became more evident as the mean number of live aphids after 48 hours from the June 19 samples dropped from 4.2 to 1.5 and 5.6 to 3.5 in Fields 1 and 2, respectively. Field 3 appeared to have an adequate insecticide concentration present at all three samplings. The mean number of live aphids in all three fields at early samplings was less than the check suggesting the presence of insecticides.

Field 2 received the most moisture of the three fields and, although plants in Field 2 were the youngest, they reached their peak greenbug infestation prior to Field 1 or 3. Similarily, the greenbug population in Field 1 received slightly more moisture than Field 3 and reached its population peak prior to Field 3. All fields reached their peak population ca. 12-20 days after planting. No measurable moisture fell between June 10 and June 20. Results obtained indicate that moisture and plant age are important factors in insecticide uptake. These

EXPLANATION OF FIGURE 1

Maximum number of greenbugs per plant
for three fields in Saline County, Kansas,
at designated number of days after planting

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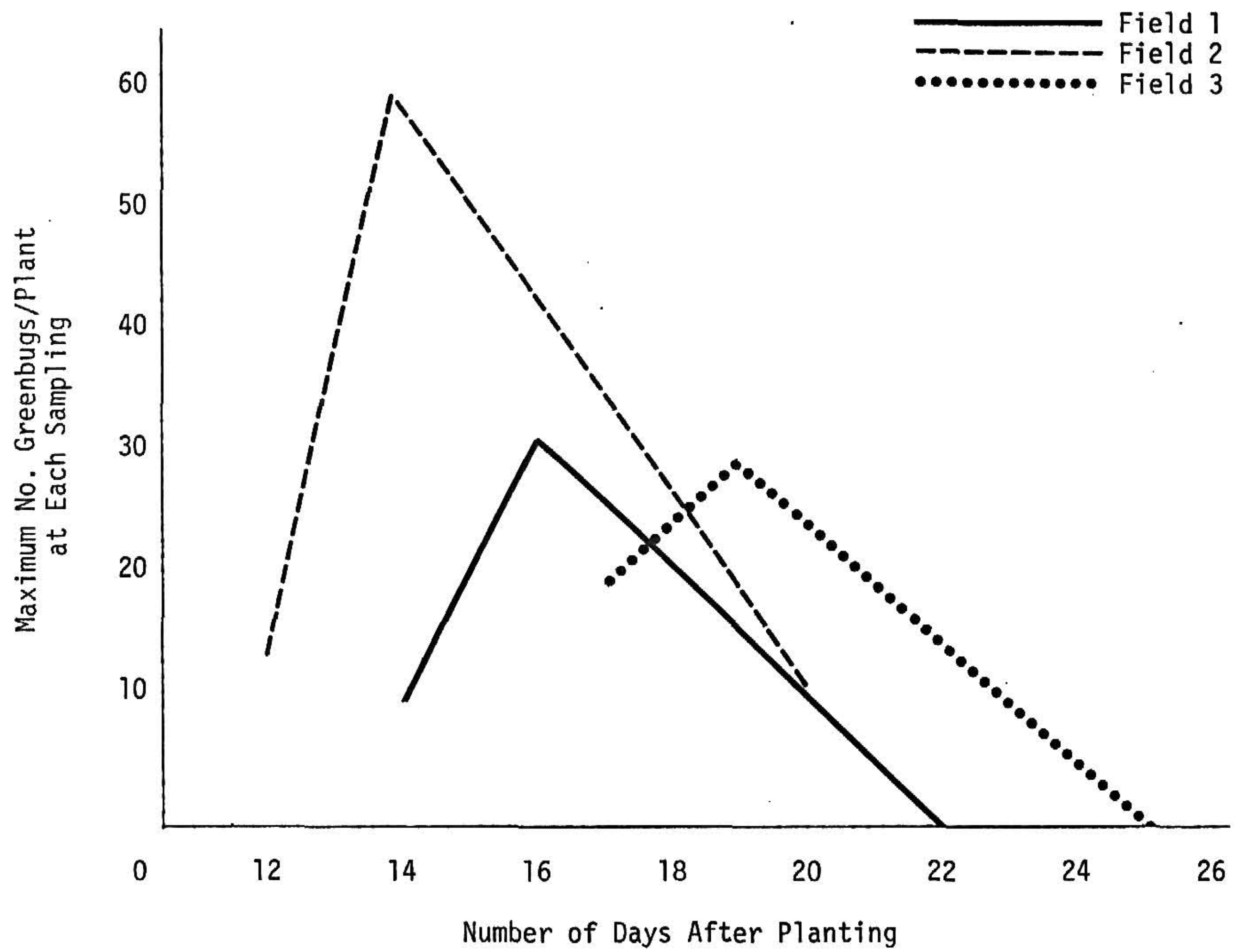
Field 1
Field 2
Field 3
Maximum No. Greenbugs/Plant at Each Sampling
60
50
40
30
20
10
0
12
14
16
18
20
22
24
26
Number of Days After Planting

Figure 1

Table 4. Bioassay of disulfoton treated plants. Based on mean number of live greenbugs after 48 hours on plant samples obtained from three fields in Saline County, Kansas. 1973.

Field Number	Sampling Date		
	June 11	June 13	June 19
1	4.6 (14)[a]	4.2 (16)	1.5 (22)
2	4.6 (12)	5.6 (14)	3.5 (20)
3	1.8 (17)	1.5 (19)	0.1 (25)
Check[b]	7.4	7.2	6.1

[a]Numbers in parenthesis indicate number of days after planting at sampling date.

[b]Untreated RS-701 sorghum.

results support DePew's (1971) findings in which he lists gradual absorption qualities of granules and moisture as vital factors in insecticide performance. These results also suggest that the presence of a few greenbugs on treated seedling sorghum does not necessarily mean the grower should be overly concerned. The plants require 12-20 days to actively take up and distribute insecticides.

Table 5 depicts the results of the insecticide/herbicide combinations test conducted at Ottowa. There were no significant interactions between insecticides and herbicides. The performance of insecticide/herbicide combinations was comparable to the use of insecticides alone. There was a significant increase in greenbug numbers between the 15- and 34-day sampling suggesting a reduction in the efficacy of the insecticides. Treatments containing disulfoton were consistently more efficient in controlling greenbugs than treatments containing phorate or carbofuran.

The results of herbicide/insecticide studies at Ashland are summarized in Table 6. The Ashland test results support findings of Ottowa Tests. There were no significant interactions between insecticides and herbicides. However, at the 9-day sampling the mean number of live greenbugs on the treatment of Igran (2.0 lb/acre) plus GS 13529 (0.8 lb/acre) plus phorate (1 lb/acre) was slightly larger than the check suggesting there might be an interaction among these chemicals. At the 27-day sampling the mean number of live greenbugs on the check was significantly larger. Based on these results there were no antagonistic effects to the insecticides tested when used with the herbicides tested. In some instances phytotoxicity may result from insecticide/herbicide combinations; therefore, the grower must be aware of precautions listed

Table 5. Bioassay of selected herbicide/insecticide combinations based on the ability of apterous greenbugs to survive and reproduce for 48 hours on plant samples obtained 15 and 34 days after planting. East Central Experiment Field, Ottowa, Kansas. 1973.

Herbicide/Insecticide Combinations	Mean no. of live greenbugs	
	15 days	34 days
Ramrod + Disulfoton	0.5	4.2
Ramrod + Carbofuran	3.6	5.9
Ramrod + Phorate	3.1	7.9
Ramrod + Atrazine + Disulfoton	1.2	1.5
Ramrod + Atrazine + Carbofuran	2.4	6.4
Ramrod + Atrazine + Phorate	3.3	5.9
Igran + Disulfoton	1.2	1.4
Igran + Carbofuran	3.6	4.7
Igran + Phorate	3.3	6.7
Igran + Propazine + Disulfoton	1.8	3.7
Igran + Propazine + Carbofuran	2.0	6.9
Igran + Propazine + Phorate	2.1	7.7
Herban 21A + Disulfoton	2.0	3.6
Herban 21A + Carbofuran	3.5	4.4
Herban 21A + Phorate	2.6	6.3
Disulfoton	2.8	1.9
Carbofuran	2.6	7.3
Phorate	4.1	6.1
No Treatment	5.3	7.9

Table 6. Bioassay of selected herbicide/insecticide combinations based on the ability of apterous greenbugs to survive and reproduce for 48 hours on plant samples obtained 9 and 27 days after planting. Ashland Agronomy Farm, Ashland, Kansas. 1973.

Herbicide Combinations[a]	Mean no. of live greenbugs					
	9 days			27 days		
	Disulfoton	Phorate	Check	Disulfoton	Phorate	Check
Igran (2.4)	2.7	4.9	6.7	-	-	-
Igran (2.0) + Propazine (0.8)	2.0	2.6	4.3	-	-	-
Igran (2.0) + Atrazine (0.8)	0.8	1.9	6.3	1.1	9.6	10.6
Herban 21A (2.4)	1.3	4.1	-	-	-	-
Ramrod (4.0)	2.5	3.3	8.0	-	-	-
Igran (2.0) + GS 13529 (0.8)	2.1	4.7	4.0	2.9	7.3	14.2
Igran (2.0) + Atrazine (0.8)[b]	1.7	2.7	6.2	2.5	8.4	7.0

[a]Numbers in parenthesis indicate application rates (lbs/acre).

[b]Postemergence herbicide application. Herbicide applied after 9-day sampling.

on the labels of compounds in use. These results are in agreement with Chambers' et al. (1969) observations in which they noted combinations of selected insecticide and herbicides had no detrimental affect on early-season insect control.

Results of the predator study are presented in Tables 7 through 10. *O. insidiosus* (Table 7) did not survive on sorghum which had not been infested with greenbugs. This was probably due to starvation. On plants which were infested with greenbugs but untreated, *O. insidiosus* survived well. On treated plants infested with greenbugs, some *O. insidiosus* survived but mortality was considerably higher than mortalities occurring on untreated, infested plants. The *O. insidiosus* tests suggest that systemic insecticides can directly affect predators. The mechanism by which this effect is achieved is not know. However, it was likely that *O. insidiosus* feeds on plant tissue and could have been affected by the insecticide in the same manner as the greenbug. These results support observations made by York (1944) of certain predators feeding directly on plants. The feeding on plant material by predators might be an attempt to obtain moisture or nutrients available only in the plant.

The *Chrysopa* sp. larvae (Table 8) survival rate on untreated, infested plants averaged only 50%. This might be due to the fragile nature of the *Chrysopa* sp. larvae; they were difficult to handle and died easily. Larvae survival on infested, treated plants was low although not significantly lower suggesting a detrimental effect of the insecticide on the larvae. These results are not in agreement with the observations of Ahmed et al. (1954) in which they reported low mortality

Table 7. Bioassay of disulfoton on *Orius insidiosus* (Say) adults. Based on percent survival of *O. insidiosus* adults for 4 days when caged on treated and untreated plants. Manhattan, Kansas. 1973.

Test Number	Disulfoton		Untreated	
	% survival when infested[a]	% survival when not infested[b]	% survival when infested[a]	% survival when not infested[b]
1	17	0	83	0
2	33	0	83	0
3	17	0	100	17

[a]Infested with greenbugs

[b]Not infested with greenbugs

Table 8. Bioassay of disulfoton on *Chrysopa* sp. larvae. Based on percent survival of *Chrysopa* sp. larvae for 4 days when caged on treated and untreated plants. Manhattan, Kansas. 1973.

Test Number	Disulfoton		Untreated	
	% survival when infested[a]	% survival when not infested[b]	% survival when infested[a]	% survival when not infested[b]
1	75	0	25	0
2	0	0	58	0
3	0	0	50	0

[a]Infested with greenbugs

[b]Not infested with greenbugs

rates (2%) of Chrysopidae larvae when fed aphids which had been feeding on Systox treated plants.

H. convergens larvae (Table 9) did not survive well on uninfested plants. The data indicate larvae survived as well on treated, infested plants as on untreated, infested plants. *Nabis* sp. adults (Table 10) responded in a manner similar to the *H. convergens* larvae; however, the *Nabis* sp. survived equally well on treated and untreated uninfested plants. Unlike the *O. insidiosus* and *Chrysopa* sp., the *H. convergens* and *Nabis* sp. seem to be less affected by systemic insecticides. The effect of insecticides on predators might vary from species to species. Different reactions to insecticides might be due to factors such as body size, hardiness, physiology, or, probably most important, the insecticide being used. Different insecticides affect insects, as well as different stages within the same species, in different manners. This is supported by tests conducted by Hamilton and Kieckhefer (1969) in which adult Coccinellidae were more susceptible to malathion than the larvae of the same species.

The results of yield tests conducted at Peabody are presented in Table 11. On June 8 the greenbug population was ca. 200-300 per plant over the entire field. By June 13 the population had increased to 200-500 per plant with the exception of plots treated June 8 where the population had been virtually eliminated. By June 19 the field population had been eliminated as a result of an application of dimethoate on June 13. The check plots maintained a greenbug population of ca. 0-27 greenbugs per plant. This small population was probably due to large numbers of Braconid wasp parasites. After June 20 the greenbug

Table 9. Bioassay of disulfoton on *Hippodamia convergens* Guerin-Meneville larvae. Based on percent survival of *H. convergens* larvae for 4 days when caged on treated and untreated plants. Manhattan, Kansas. 1973.

Test Number	Disulfoton		Untreated	
	% survival when infested[a]	% survival when not infested[b]	% survival when infested[a]	% survival when not infested[b]
1	8	41	41	41
2	100	0	100	0
3	100	0	83	0

[a]Infested with greenbugs

[b]Not infested with greenbugs

Table 10. Bioassay of disulfoton on *Nabis* sp. adults. Based on percent survival of *Nabis* sp. adults for 4 days when caged on treated and untreated plants. Manhattan, Kansas. 1973.

Test Number	Disulfoton		Untreated	
	% survival when infested[a]	% survival when not infested[b]	% survival when infested[a]	% survival when not infested[b]
1	58	67	83	67
2	100	67	83	67

[a]Infested with greenbugs

[b]Not infested with greenbugs

Table 11. Effect on yield of heavy greenbug infestations occurring on seedling grain sorghum. Marion County, Kansas. 1973.

Treatment	Date sampled and treated	Greenbugs/ plant prior to treatment	No. of leaves killed	Leaves showing reddened appearance	Stage of growth[a]	Plant height (inches)	Yield lb/acre
Disulfoton	June 8	200-300	0	1	2-3	4-6	5591.0
Dimethoate	June 13	200-300	1	2-3	3-4	11	4666.3
Check	June 19[b]	0-27	1	2-3	3-4	27-30	4063.9

[a]Plant growth stage (Vanderlip, 1972)
2-Collar of fifth leaf visible
3-Growing point differentiation
4-Final leaf visible in whorl

[b]No treatments on June 19

population was virtually eliminated as a result of parasitization. In a period of 11 days (June 8-19), the heavy greenbug infestation reduced the yield from 5591 lbs/acre in the plots treated June 8 to 4063.9 lbs/acre in the untreated plots, a significant difference of 1527.1 lbs/acre (F test, 5% level). Delaying controls by 5 days reduced yields from 5591 to 4666.3 lbs/acre, a difference of 924.7 lbs/acre. Although this difference is not significant at the 5% level of probability, it reflects the importance of chemical applications when greenbug populations reach high levels on seedling plants. Harvey and Hackerott (1970) list stage of plant growth during time of infestation and intensity of infestation as factors affecting yields. More recently Harvey and Hackerott (1974) observed substantial yield reductions when susceptible seeding sorghum was heavily infested with greenbugs.

CONCLUSIONS

Cate et al. (1973) list several advantages and disadvantages for planting time applications. The advantages include 1) relative ease of application, 2) elimination of the guesswork in differentiating greenbugs and corn leaf aphids and assessing their population abundance, and 3) assurance against economic damage by greenbugs at all times during the growing season. The disadvantages include 1) the possibility of no economic greenbug infestations, 2) preventative control for younger plants has not been necessary because infestations are heaviest and cause greatest damage later in the season, 3) preventative treatments would constitute a cost to the producer that would not be required, 4) less expensive alternative methods of greenbug control are available for major population increases, mainly foliar sprays, and 5) applications of preventive treatments of systemic insecticides at planting might produce disasterous ecological upset by direct or indirect suppressive affect on natural enemies thus increasing the chance of outbreaks of secondary pests.

The purpose of this study was to gain further insight into the greenbug and the problems it represents to the grower. The results are in basic agreement with Cate et al. (1973). All compounds provided some control of greenbugs. Results indicate placement as having little affect on initial greenbug control. Growers experiencing potential greenbug population buildup on treated seedling sorghum should be aware that moisture and plant growth stage probably regulate the speed of insecticide uptake. Although greenbug populations should decline as the treated plant grows, the plants should be watched for extensive population buildups and, most important, plant damage.

Results indicated that granular disulfoton when utilized as a systemic for control of greenbugs has detrimental affects on *O. insidiosus* adults. *Chrysopa* sp. larvae responded similarly to *O. insidiosus*; however, results were not conclusive enough to state that disulfoton adversely affects *Chrysopa* sp. Additional research needs to be conducted to determine the exact effects of disulfoton. *Nabis* sp. adults and *H. convergens* larvae appeared to be unaffected by disulfoton. Additional research should be conducted to determine the affects of compounds other than disulfoton on greenbug predators as well as the affects these compounds have on different developmental stages of greenbug predators.

The results of tests conducted at Ottowa and Ashland, Kansas, indicated no synergistic or antagonistic effects with regard to greenbug control when the compounds tested were used in the combinations listed. Growers must be familiar with the compatibility of different pesticides. Phytotoxic reactions should be considered; however, the grower should also be aware of any alteration in the effectiveness of insecticides resulting from herbicide/insecticide interactions.

The yield of heavily infested seedling sorghum was severely reduced by not treating. Growers who fail to treat at planting time must be constantly aware of greenbug populations on young sorghum. If greenbug populations begin an upsurge, immediate action should be taken by the grower to suppress the buildup and avoid lower yields.

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A STUDY OF PLANTING TIME APPLICATIONS FOR GREENBUG CONTROL ON GRAIN SORGHUM

by

HARLAN DEAN FEESE

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The purpose of this study was to investigate the effect of 1) placement and formulation of selected insecticides on the initial and residual control of greenbugs on seedling and older grain sorghum, 2) granular systemic insecticides on selected greenbug predators, 3) seedling infestations of greenbugs on sorghum yields, and 4) selected herbicides on granular systemic insecticides with regard to synergistic or antagonistic reactions in controlling greenbugs.

Placement and formulation of insecticides were tested at Rocky Ford Agronomy Farm near Manhattan, Kansas. Band, furrow, and seed treatments of selected compounds were applied to grain sorghum. All compounds provided some greenbug control. There was no significant difference between band or furrow placements. All compounds appeared to be less effective after 60 days. Of the registered compounds, DiSyston appeared to provide the best residual control. Seed treatments were also tested in the lab. Efficacy results were comparable to the granular tests; however, seed germination was reduced drastically under lab conditions.

A survey and lab study of three fields in Saline County, Kansas, aided in determining how rapidly insecticide uptake occurs in seedling sorghum. Although initial infestations were present, the greenbug population did not buildup. Results suggested moisture and plant growth stage are vital factors in uptake of granular systemics by seedling sorghum.

Herbicide/insecticide interaction tests were conducted near Ashland and Ottowa, Kansas. Grain sorghum was treated with selected herbicides

and granular systemic insecticide combinations at planting time. No significant difference in greenbug control occurred between treatments of insecticides and treatments of insecticide/herbicide combinations indicating antagonistic or synergistic reactions did not occur.

Preceeding tests were evaluated by cutting leaf sections or using the seedling plant, placing in a vial containing moist sand, and infesting with greenbugs.

Predator studies were conducted by caging larval Coccinellids and Chrysopids and adult Anthocorids and Nabids on sorghum. Each test consisted of DiSyston treated and untreated sorghum plants; within each treatment plants were infested with greenbugs or remained uninfested. Anthocorids and to some extent Chrysopids were adversely affected by DiSyston. Coccinellids and Nabids were not affected.

Yield studies were conducted in a field in Marion County, Kansas. The initial greenbug population was 200 to 300 per plant on 4- to 6-inch sorghum. Five rows, 100 feet long, were treated on June 8. On June 13 the entire field was treated excluding earlier treatments and check rows. A yield reduction of ca. 1527 pounds per acre occurred when heavily infested seedling sorghum was untreated even though seedlings survived the infestation. Delaying treatment of heavily infested seedling sorghum by five days reduced yields by ca. 924 pounds per acre.