Effect of Herbicides and Insecticides Applied to Sugarbeets at Planting†

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ABSTRACT

Combinations of herbicides and insecticides were compared for their effect on sugarbeet vigor, stand, and yield. The herbicide cycloate caused more sugarbeet injury than ethofumesate or diethatyl. All the insecticides evaluated caused significant stand reduction in at least one experiment. However, the organophosphate insecticides chlorpyrifos, fonofos, and terbufos caused more injury than the carbamate insecticides aldicarb or carbofuran. In two of three years, terbufos caused less sugarbeet injury than chlorpyrifos or fonofos. In one year out of three there was an interaction between herbicides and insecticides applied at planting, with cycloate causing more sugarbeet injury when combined with organophosphate insecticides than ethofumesate or diethatyl.

Additional Key Words: Aldicarb, carbofuran, chlorpyrifos, cycloate, diethatyl, ethofumesate, fonofos, terbufos, *Beta vulgaris*.

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Sugarbeet (*Beta vulgaris* L.) growers in many production areas make soil applications of pesticides at planting for control of weeds, insects, and nematodes. The pesticide in most situations is beneficial through control of the pest, but it can be detrimental if the plant is injured.

The herbicides cycloate and ethofumesate may reduce the stand and top growth of sugarbeets during crop establishment, with injury increasing on coarse textured soils and with increasing rate (Schweizer, 1979). Sugarbeet stand reduction and plant injury from cycloate, diethatyl, and ethofumesate increased as depth of seeding increased from 1.6 to 4.5 cm (Wilson, Smith, and Yonts, 1991).

Aldicarb, carbofuran, fonofos, and terbufos caused sugarbeet stand reductions of 24, 17, 94, and 37%, respectively, when applied in the seed furrow at planting (Bergen, Whitfield, and Lilly, 1986). However, aldicarb, carbofuran, and fonofos applied in the seed furrow at planting on a heavier textured soil had no detrimental effect on sugarbeets (Allen and Askew, 1966; Allen, Askew, and Klassen, 1971).

Herbicides and insecticides applied at planting may interact and cause sugarbeet injury. Combinations of cycloate and disulfoton applied at planting caused more sugarbeet injury than either pesticide applied alone (Wedderburn, Jenkins, and Schweizer, 1973). Neither aldicarb nor carbofuran in combination with cycloate plus diallate interacted to increase sugarbeet injury (Bergen, Whitfield, and Lilly, 1986). Cycloate and aldicarb combinations reduced the growth of several sugarbeet varieties, whereas combinations of EPTC and aldicarb applied under different environmental conditions did not injure sugarbeets (Abivardi and Altman, 1978; Cole and Dexter, 1985).

Research was initiated in response to several field observations in April and May of 1988. Sugarbeet growers observed poor stands and reductions in plant vigor where herbicides, insecticides, and combinations of both had been applied at planting. The amount of sugarbeet injury from pesticides applied at planting was variable and seemed to be dependent upon the pesticide, method of application, and/or environmental conditions. Although sugarbeet injury from individual and combinations of pesticides has been reported, very few pesticide labels address the problem. To aid sugarbeet growers in preventing crop injury, commonly used herbicides and insecticides were applied individually and in combination to examine their phytotoxic effects on sugarbeets.

MATERIALS AND METHODS

Experiment 1. An experiment was initiated in June of 1988 near Scottsbluff, Nebraska to evaluate the potential for selected pesticides to injure sugarbeets. The experimental design was a split plot with 3 main plots and 11 subplots. All treatments were replicated four times. Main plots were an untreated herbicide control, cycloate [S-ethyl cyclohexylethyl carbamothioate] at 2.8 kg ai ha^{-1}, and ethofumesate [($\pm$)-2-ethoxy-2,3-dihydro-3,3-dimethyl-5-benzofuranyl methanesulfonate] at 1.6 kg ha^{-1}. Subplots were aldicarb [2-methyl-2-(methylthio)propionaldehyde O-methylcarbamoyl) oxime], carbofuran [2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate], chlorpyrifos [O,O-diethyl O-(3,5,6-trichloro-2-pyridinyl) phosphorothioate], and terbufos [S-(((1,1-dimethylethyl)thio)methyl) O,O-diethylphosphorodithioate] at 2.2 and 6.7 kg ha^{-1}, fonofos [O--ethyl-S-phenylethylphosphonodithioate] at 1.6 and 4.8 kg ha^{-1}, and an untreated control. The higher insecticide rates were used for comparison to the lower registered rates and to determine the sensitivity of sugarbeets to increased rates. Field observations have indicated that insecticide metering and distribution units may result in over-applications of two or three times the registered rate. Individual subplots were two sugarbeet rows wide by nine m long. Sugarbeet emergence and vigor data were subjected to analysis of variance and mean separations were performed by orthogonal single degree of freedom contrasts.

The soil was a Glenberg fine sandy loam (Ustic Torrifluvents) with pH 8.3 and 0.8% organic matter content. The field was moldboard plowed and roller harrowed in early June. Preplant herbicides were applied on June 27 and immediately incorporated with a roller harrow to a depth of two to five cm. Herbicides were broadcast applied in water at 200 L ha^{-1} with a tractor-mounted sprayer. Sugarbeets, 'Hilleshog Mono-Hy 55' were planted June 28 with a John Deere 71 planter in rows spaced 56 cm apart at a rate of 4 seeds per 30 cm of row. Insecticides were applied as granular formulations in a 17.8 cm band over the sugarbeet row after the crop was planted with a bicycle type push applicator equipped with a Noble metering unit (Remcor, Inc , 504 So. Deny, Box 717, Howe TX 75909). Insecticide granules were incorporated on the soil surface with a drag chain. Sugarbeets were irrigated on June 29 with an overhead sprinkler which delivered 2.5 cm of water. All plots were kept weed free with handweeding and cultivation and were irrigated as needed throughout the season. Insects were not a problem in this experiment.

Visual estimates of sugarbeet injury (0 = no injury and 100 = completely killed) were recorded on July 26. Sugarbeet plants were

counted on July 15 and 27 from two rows for a distance of 9 m.
Experiment 2. Field experiments were conducted near Scottsbluff, Nebraska, in 1989, and near Scottsbluff and Mitchell in the spring of 1990. The experimental design was a split plot with 4 main plots and 11 subplots. All treatments were replicated four times. Main plots were an untreated herbicide control, cycloate at 2.8 kg ha^{-1}, ethofumesate at 1.6 kg ha^{-1}, and diethatyl [N-(chloroacetyl)-N-(2,6-diethylphenyl)glycine] at 3.3 kg ha^{-1}. Subplots were aldicarb, carbofuran, and chlorpyrifos at 2.2 and 4.5 kg ha^{-1}, terbufos at 2.0 and 4.0 kg ha^{-1}, fonofos at 1.6 and 3.3 kg ha^{-1}, and an untreated control. Individual subplots were 2 sugarbeet rows wide by 15 m long. Year by location by main plot and subplot interactions were significant; therefore, the data for each year and location were subjected to separate analyses of variance. Main plot and subplot effects and their interactions were subdivided and compared by single degree of freedom orthogonal contrasts.

The Scottsbluff plots were located on a Glenberg fine sandy loam (Ustic Torrifluvents) with pH 8.3 and 0.8% organic matter content; the Mitchell plots were on a Tripp sandy loam (Typic Haplustoll) with pH 8 and 1% organic matter content. Experimental plots, located in a different field each year, were moldboard plowed and roller harrowed during the first week of April. Preplant herbicides were applied during the second week of April and immediately incorporated with a roller harrow to a depth of 2 to 5 cm. Herbicides were broadcast applied in water at 200 L ha^{-1} with a tractor-mounted sprayer. In the second week of April, sugarbeets, 'Hilleshog Mono-Hy 55' were planted with a John Deere 71 planter in rows spaced 56 cm apart, at a rate of 4 seeds per 30 cm of row, at a depth of 2.5 cm. Insecticide application procedures for 1989 were identical to those used in 1988. In 1990, insecticides were applied as granular formulations in a 13 cm band over the sugarbeet row in front of the planter press wheel during the planting operation. Insecticide granules were metered over the sugarbeet row with Noble metering units and incorporated on the soil surface with a drag chain.

The 1989 Scottsbluff experiment was irrigated 2 days after planting with 2.5 cm of water from an overhead irrigation system. Substantial stand loss resulted from a freeze April 29, and the crop was replanted into the existing sugarbeet row on May 1. Herbicides and insecticides were not reapplied. In 1990 the Scottsbluff and Mitchell locations received 1.1 cm of rainfall 2 and 6 days, respectively, after planting. All plots were kept weed free with handweeding and cultivation and beginning the first of July were irrigated as needed throughout the season. Insects were not a problem at either location in 1989 or 1990.

Visual estimates of sugarbeet injury (0 = no injury and 100 = completely killed) were recorded in mid-May and early June. Sugarbeet stand was determined by counting all plants in each plot. Counts began two weeks after seeding and continued at weekly intervals until the first of June. Sugarbeets were topped, harvested, and weighed during early October with a mechanical two-row harvester. A 9-kg subsample from each plot was washed, weighed, and analyzed for sucrose content by the method outlined by the Association of Official Agriculture Chemists (1955).

RESULTS AND DISCUSSIONS

Experiment 1. Sugarbeet stands and vigor were not abnormally affected by herbicides applied before the crop was planted (Table 1). When compared to an untreated control, insecticide treatments reduced the stands of sugarbeets when the crop was observed on July 15 and 27. The organophosphate insecticides chlorpyrifos, fonofos, and terbufos caused more vigor loss and stand reduction on July 27 than did the carbamate insecticides aldicarb and carbofuran. Aldicarb and carbofuran differed in their effect on sugarbeets, with carbofuran causing more sugarbeet stand reduction than aldicarb. As carbofuran rate increased from 2.2 to 6.7 kg ha^{-1}, the sugarbeet stand on July 27 decreased from 40 to 24 plants per 15 m of row. The organophosphate insecticide chlorpyrifos caused more sugarbeet injury than fonofos and reduced sugarbeet stands 57% as compared to the untreated control. As both chlorpyrifos and fonofos rates of application were increased, there was a decrease in sugarbeet stand. There were no interactions between herbicides and insecticides.

Experiment 1 was conducted from late June through mid-August when air temperatures averaged 23 C. Sugarbeets normally are planted the first of April, and under normal growth conditions, air temperatures from mid-April to mid-May would average 10 C. Even though mean air temperature in experiment 1 was warmer than would be expected in the spring, it appears that insecticides have the potential to cause substantial sugarbeet injury.

Experiment 2. In 1989, herbicides caused an 8% increase in sugarbeet injury compared to the untreated control (Table 2). Cycloate caused more injury and sugarbeet stand reduction than did ethofumesate or diethatyl. None of the early season sugarbeet injury caused by herbicides resulted in a reduction of sucrose percent (data not presented) or yield as compared to the untreated control.

Sugarbeet injury from insecticides was minor in 1989 (Table 2). The organophosphate insecticides chloropyrifos, fonofos, and terbufos caused more visual sugarbeet injury than aldicarb and carbofuran. The injury did not persist and sugarbeet stand, sucrose percent, and yield were not affected. Within the organophosphate insecticides, fonofos reduced sugarbeet stand 17% as compared to chlorpyrifos; the injury from fonofos increased as the rate of application increased. There was no interaction between herbicides and insecticides.

In 1989, sugarbeet injury from insecticides was much less than that observed in 1988. In 1989, sugarbeets were planted on April 11 and replanted on May 1 after a hard freeze on April 29. From April 11 to May 1 the plots received 7.6 cm of moisture. The effect of both the herbicides and insecticides probably was reduced on the replanted sugarbeets due to the 20 days that had elapsed, allowing breakdown and movement of the insecticides, plus the mixing and dilution of the pesticides resulting from replanting.

Table 1. Response of sugarbeets to herbicides and insecticides applied at the time of planting at Scottsbluff, Nebraska, in 1988.

	Sugarbeet					
Contrasts	Vigor loss	Significance of F values	Stand 7/15	Significance of F values	Stand 7/27	Significance of F values
	(%)		(plants per 15 m row)		(plants per 15 m row)	
Main plot						
No herbicide vs. herbicide	16 vs. 23	NS	43 vs. 46	NS	38 vs. 39	NS
Cycloate vs. ethofumesate	27 vs. 19	NS	44 vs. 47	NS	35 vs. 42	NS
Subplots						
No insecticide vs. insecticide	19 vs. 21	NS	72 vs. 42	**	65 vs. 36	**
Aldicarb and carbofuran vs. chlorpyrifos, fonofos, and terbufos	11 vs. 27	**	42 vs. 41	NS	40 vs. 34	**
Aldicarb vs. carbofuran	9 vs. 13	NS	50 vs. 35	**	47 vs. 32	**
Aldicarb 2.2 vs. 6.7 kg ha^{-1}	10 vs. 8	NS	51 vs. 48	NS	49 vs. 45	NS
Carbofuran 2.2 vs. 6.7 kg ha^{-1}	13 vs. 14	NS	42 vs. 28	*	40 vs. 24	**
Terbufos vs. chlorpyrifos and fonofos	24 vs. 28	NS	39 vs. 43	NS	33 vs. 34	NS
Terbufos 2.2 vs. 6.7 kg ha^{-1}	23 vs. 25	NS	43 vs. 35	NS	35 vs. 31	NS
Chlorpyrifos vs. fonofos	33 vs. 24	*	39 vs. 46	*	28 vs. 40	**
Chlorpyrifos 2.2 vs. 6.7 kg ha^{-1}	31 vs. 34	NS	46 vs. 33	*	36 vs. 20	**
Fonofos 1.6 vs. 4.8 kg ha^{-1}	22 vs. 26	NS	52 vs. 40	*	48 vs. 32	**
Main plot X subplot interaction		NS		NS		NS

*, **Significant at 0.05 and 0.01 probability levels, respectively; NS = not significant.

Table 2. Response of sugarbeets to herbicides and insecticides applied at the time of planting at Scottsbluff, Nebraska, in 1989.

	Sugarbeet							
Contrasts	Vigor loss	Significance of F values†	Stand 5/26	Significance of F values	Stand 6/6	Significance of F values†	Yield	Significance of F values
	(%)		(plants per 15 m row)		(plants per 15 m row)		(t ha^{-1})	
Main plot								
No herbicide vs. herbicide	5 vs. 13	**	37 vs. 34	NS	32 vs. 33	NS	42.1 vs. 43.5	NS
Cycloate vs. ethofumesate and diethatyl	22 vs. 8	**	39 vs. 32	*	36 vs. 31	**	43.6 vs. 43.5	NS
Ethofumesate vs. diethatyl	10 vs. 6	NS	33 vs. 31	NS	31 vs. 31	NS	44.8 vs. 42.1	NS
Subplots								
No insecticide vs. insecticide	13 vs. 11	NS	37 vs. 35	NS	35 vs. 32	NS	42.1 vs. 43.3	NS
Aldicarb and carbofuran vs. chlorpyrifos, fonofos, and terbufos	8 vs. 13	**	35 vs. 35	NS	33 vs. 32	NS	42.8 vs. 43.6	NS
Aldicarb vs. carbofuran	7 vs. 10	NS	37 vs. 33	NS	34 vs. 31	NS	40.8 vs. 44.9	NS
Aldicarb 2.2 vs. 4.5 kg ha^{-1}	8 vs. 11	NS	32 vs. 34	NS	31 vs. 31	NS	42.2 vs. 47.6	NS
Carbofuran 2.2 vs. 4.5 kg ha^{-1}	7 vs. 7	NS	35 vs. 39	NS	32 vs. 36	NS	39.1 vs. 42.5	NS
Terbufos vs. chlorpyrifos and fonofos	11 vs. 13	NS	35 vs. 34	NS	33 vs. 32	NS	48.5 vs. 41.1	**
Terbufos 2.0 vs. 4.0 kg ha^{-1}	11 vs. 12	NS	34 vs. 37	NS	31 vs. 35	NS	48.3 vs. 48.6	NS
Chlorpyrifos vs. fonofos	11 vs. 15	NS	37 vs. 32	NS	35 vs. 29	*	42.7 vs. 39.5	NS
Chlorpyrifos 2.2 vs. 4.5 kg ha^{-1}	11 vs. 12	NS	38 vs. 35	NS	35 vs. 35	NS	42.5 vs. 42.9	NS
Fonofos 1.6 vs. 3.3 kg ha^{-1}	14 vs. 17	NS	36 vs. 28	*	33 vs. 26	*	42.7 vs. 36.3	NS
Main plot X subplot interaction		NS		NS		NS		NS

*, **Significant at 0.05 and 0.01 probability levels, respectively; NS = not significant.

In 1990 at Scottsbluff and Mitchell, sugarbeet vigor and stands on the second observation date were reduced by herbicides (Tables 3 and 4). Cycloate caused more visual injury, stand loss, and yield reduction than ethofumesate and diethatyl. Ethofumesate and diethatyl did not differ in their effect on sugarbeets at Scottsbluff, but at Mitchell ethofumesate caused more injury than diethatyl. Sucrose content was not affected by herbicides at either location (data not presented).

Insecticide treatments increased sugarbeet injury at Scottsbluff, reduced stand and yield at both Scottsbluff and Mitchell, and had no effect on sucrose content at either location (Tables 3 and 4). The organophosphate insecticides chlorpyrifos, fonofos, and terbufos caused more sugarbeet stand and yield reduction than aldicarb and carbofuran. Within the carbamate insecticides, aldicarb reduced sugarbeet stands more than carbofuran. At Scottsbluff, aldicarb also caused a 5.6 t ha^{-1} yield reduction as compared to carbofuran. As aldicarb rate was increased from 2.2 to 4.5 kg ha^{-1}, sugarbeet stands decreased 14%. As carbofuran rate was increased from 2.2 to 4.5 kg ha^{-1} sugarbeet stand did not change but injury increased and yield decreased. Among the organophosphate insecticides, terbufos caused less sugarbeet stand and yield reduction than chlorpyrifos and fonofos. Terbufos injury in the form of stand reduction at Mitchell or visual injury, stand, and yield reduction at Scottsbluff increased as terbufos rate increased from 2.0 to 4.0 kg ha^{-1}. Fonofos reduced sugarbeet stand to a greater extent than chlorpyrifos at both Scottsbluff and Mitchell. At Mitchell, sugarbeet yield was reduced more by chlorpyrifos than fonofos. At both locations chlorpyrifos and fonofos caused more sugarbeet stand and yield reductions as the rate increased.

At both locations in 1990 there was a interaction between herbicides and insecticides (Tables 3 and 4). At Scottsbluff, significant interactions were observed for the variables sugarbeet vigor and yield; at Mitchell interactions were significant for sugarbeet vigor, stand, and yield. On cycloate treated plots at Scottsbluff, root yield decreased from 77.7 t ha^{-1} without insecticides to 64.5 t ha^{-1} with insecticides. In comparison, on ethofumesate and diethatyl treated plots, root yield varied from 72.5 to 73.4 t ha^{-1} with and without insecticides, respectively. The interaction of cycloate, ethofumesate, and diethatyl with organophosphate and carbamate insecticides (BX2) was significant at both Scottsbluff and Mitchell. On cycloate treated plots at Mitchell, root yield decreased from 62.9 t ha^{-1} with carbamate insecticides to 44.9 t ha^{-1} with organophosphate insecticides. In comparison, on ethofumesate and diethatyl treated plots, root yields decreased from 62.5 to 55.3 t ha^{-1} with carbamate and organophosphate insecticides, respectively.

At Scottsbluff, sugarbeet yield declined when terbufos (62.9 t ha^{-1}) or chlorpyrifos and fonofos (59.3 t ha^{-1}), were applied to cycloate treated plots. In comparison, on ethofumesate and diethatyl treated plots, root yields decreased with terbufos (78.4 t ha^{-1}) or chlorpyrifos and fonofos (66.3 t ha^{-1}).

The amount of sugarbeet injury from pesticides applied at planting was variable from 1988 to 1990, and seemed to be dependent upon the environmental conditions following planting. Herbicides had the potential to reduce sugarbeet vigor and stand with cycloate causing more injury than ethofumesate or diethatyl. Insecticides also had the potential to reduce sugarbeet vigor and stand and, in some situations, root yield. The organophosphate insecticides chlorpyrifos, fonofos, and terbufos caused more sugarbeet injury than the carbamate insecticides aldicarb or carbofuran. Within both insecticide families, the degree of plant injury from individual insecticides varied from year to year. In 1988 carbofuran caused more injury than aldicarb; in 1990 aldicarb was more injurious than carbofuran. Within the organophosphates, terbufos caused less sugarbeet injury than chlorpyrifos or fonofos. In 1988 chlorpyrifos caused more injury than fonofos, whereas in 1989 and 1990 fonofos was more injurious than chlorpyrifos. In 1990 at both locations the herbicide cycloate interacted with insecticides and, in particular, organophosphate insecticides to increase sugarbeet injury.

Sugarbeet injury in the form of vigor loss and stand reductions was common from pesticides in 1988, 1989, and 1990. In 1990, pesticides caused increased crop injury and stand reductions which eventually resulted in sugarbeet yield reduction. Growing conditions in 1990 were ideal; rainfall occurred soon after planting, and the crop was not subjected to freezing conditions after emergence. Under these growing conditions, environmental effects did not mask the effect of pesticides.

As sugarbeet pest management programs are designed it is important to consider the advantages and disadvantages of each pesticide included. If the pest is not present, the grower should avoid using the pesticide unless the pest problem develops. Utilizing both a herbicide and an insecticide at the time of planting may increase the risk of sugarbeet injury.

Table 3. Response of sugarbeets to herbicides and insecticides applied at the time of planting at Scottsbluff, Nebraska, in 1990.

Contrasts	Sugarbeet							
	Vigor loss	Significance of F values	Stand 4/30	Significance of F values	Stand 5/29	Significance of F values	Yield	Significance of F values
	(%)		(plants per 15 m row)		(plants per 15 m row)		(t ha^{-1})	
Main plot								
A. No herbicide vs. herbicide	6 vs. 16	**	80 vs. 70	**	80 vs. 72	NS	71.4 vs. 70.4	NS
B. Cycloate vs. ethofumesate and diethatyl	28 vs. 10	**	66 vs. 71	**	63 vs. 77	**	65.7 vs. 72.7	*
C. Ethofumesate vs. diethatyl	14 vs. 6	NS	74 vs. 69	NS	78 vs. 76	NS	72.1 vs. 73.4	NS
Subplots								
1. No insecticide vs. insecticide	9 vs. 14	**	92 vs. 70	**	90 vs. 73	**	75.0 vs. 70.3	*
2. Aldicarb and carbofuran vs. chlorpyrifos, fonofos, and terbufos	13 vs. 14	NS	77 vs. 66	**	78 vs. 69	**	74.5 vs. 67.4	**
3. Aldicarb vs. carbofuran	14 vs. 13	NS	71 vs. 83	**	72 vs. 85	**	71.6 vs. 77.2	**
4. Aldicarb 2.2 vs. 4.5 kg ha^{-1}	13 vs. 15	NS	76 vs. 65	**	77 vs. 66	**	70.4 vs. 72.8	NS
5. Carbofuran 2.2 vs. 4.5 kg ha^{-1}	9 vs. 16	**	83 vs. 83	NS	86 vs. 84	NS	80.1 vs. 74.5	*
6. Terbufos vs. chlorpyrifos and fonofos	14 vs. 15	NS	71 vs. 63	**	76 vs. 66	**	73.7 vs. 64.3	**
7. Terbufos 2.0 vs. 4.0 kg ha^{-1}	11 vs. 17	**	77 vs. 65	**	80 vs. 72	*	76.4 vs. 71.1	*
8. Chlorpyrifos vs. fonofos	14 vs. 15	NS	72 vs. 54	**	72 vs. 59	**	63.3 vs. 65.3	NS
9. Chlorpyrifos 2.2 vs. 4.5 kg ha^{-1}	11 vs. 17	**	76 vs. 68	*	79 vs. 65	**	68.8 vs. 57.7	**
10. Fonofos 1.6 vs. 3.3 kg ha^{-1}	13 vs. 18	**	64 vs. 44	**	70 vs. 48	**	70.5 vs. 59.8	**

*, **Significant at 0.05 and 0.01 probability levels, respectively; NS = not significant.

Table 3 *(Continued)*. Response of sugarbeets to herbicides and insecticides applied at the time of planting at Scottsbluff, Nebraska, in 1990.

	Sugarbeet							
Contrasts	Vigor loss	Significance of F values	Stand 4/30	Significance of F values	Stand 5/29	Significance of F values	Yield	Significance of F values
	(%)		(plants per 15 m row)		(plants per 15 m row)		(t ha-1)	
Main plot X subplot interaction		**		NS		NS		**
A X 3		**		NS		NS		NS
A X 7		*		NS		NS		NS
A X 8		NS		NS		NS		**
B X 1		*		NS		NS		**
B X 2		*		NS		NS		NS
B X 4		*		NS		NS		NS
B X 6		*		NS		NS		*
B X 7		**		NS		NS		**
B X 8		**		NS		NS		NS
B X 9		*		NS		NS		NS
C X 6		NS		NS		NS		*

*, **Significant at 0.05 and 0.01 probability levels, respectively; NS = not significant.

Table 4. Response of sugarbeets to herbicides and insecticides applied at the time of planting at Mitchell, Nebraska, in 1990.

Contrasts	Sugarbeet Vigor loss	Significance of F values	Stand 4/30	Significance of F values	Stand 5/29	Significance of F values	Yield	Significance of F values
	(%)		(plants per 15 m row)		(plants per 15 m row)		(t ha^{-1})	
Main plot								
A. No herbicide vs. herbicide	3 vs. 11	**	30 vs. 25	NS	68 vs. 62	*	54.1 vs. 56.9	NS
B. Cycloate vs. ethofumesate and diethatyl	15 vs. 9	*	22 vs. 26	NS	52 vs. 67	**	52.8 vs. 59.0	*
C. Ethofumesate vs. diethatyl	13 vs. 6	*	25 vs. 27	NS	66 vs. 69	NS	57.1 vs. 60.9	NS
Subplots								
1. No insecticide vs. insecticide	7 vs. 9	NS	30 vs. 25	NS	76 vs. 62	**	64.6 vs. 55.3	**
2. Aldicarb and carbofuran vs. chlorpyrifos, fonofos, and terbufos	7 vs. 11	**	29 vs. 23	*	71 vs. 57	**	62.7 vs. 50.4	**
3. Aldicarb vs. carbofuran	6 vs. 8	NS	26 vs. 31	NS	74 vs. 67	*	63.7 vs. 61.7	NS
4. Aldicarb 2.2 vs. 4.5 kg ha^{-1}	8 vs. 7	NS	28 vs. 34	NS	68 vs. 67	NS	60.2 vs. 63.3	NS
5. Carbofuran 2.2 vs. 4.5 kg ha^{-1}	7 vs. 5	NS	22 vs. 31	NS	78 vs. 70	NS	62.9 vs. 64.6	NS
6. Terbufos vs. chlorpyrifos and fonofos	10 vs. 12	NS	25 vs. 22	NS	61 vs. 55	*	55.3 vs. 48.1	**
7. Terbufos 2.0 vs. 4.0 kg ha^{-1}	9 vs. 11	NS	25 vs. 25	NS	66 vs. 56	*	57.1 vs. 53.3	NS
8. Chlorpyrifos vs. fonofos	12 vs. 12	NS	27 vs. 18	*	57 vs. 52	*	42.9 vs. 53.3	**
9. Chlorpyrifos 2.2 vs. 4.5 kg ha^{-1}	8 vs. 17	**	32 vs. 22	*	67 vs. 48	**	49.5 vs. 36.2	**
10. Fonofos 1.6 vs. 3.3 kg ha^{-1}	10 vs. 14	NS	23 vs. 13	*	59 vs. 44	**	58.2 vs. 48.5	**

*, ** Significant at 0.05 and 0.01 probability levels, respectively; NS = not significant.

Table 4 *(Continued)* Response of sugarbeets to herbicides and insecticides applied at the time of planting at Mitchell, Nebraska, in 1990.

	Sugarbeet							
Contrasts	Vigor loss	Significance of F values	Stand 4/30	Significance of F values	Stand 5/29	Significance of F values	Yield	Significance of F values
	(%)		(plants per 15 m row)		(plants per 15 m row)		(t ha^{-1})	
Main plot X subplot interaction		*		NS		*		**
A X 2		NS		NS		*		NS
B X 2		*		NS		**		**
B X 6		NS		NS		**		NS
B X 7		*		NS		NS		**
B X 8		**		NS		*		**
C X 2		NS		NS		NS		**
C X 5		NS		NS		NS		*
C X 9		*		NS		*		NS

*,**Significant at 0.05 and 0.01 probability levels, respectively; NS = not significant.

LITERATURE CITED

Abivardi, C. and J. Altman. 1978. Effect of cycloate and aldicarb alone and in combination on growth of three sugarbeet species (*Beta* spp.) Weed Sci. 26:161-162.

Allen, W.R. and W.L. Askew. 1966. Evaluation of insecticides for control of the sugarbeet root maggot in Manitoba. Proc. Ent. Soc. Manitoba 22:65-71.

Allen, W.R., W.L. Askew, and M. Klassen. 1971 Effect of insecticides in combination with phosphate starter fertilizers on sugar-beet root maggot control and yield of sugar beet in Manitoba. Manitoba Entomologist 5:40-48.

Association of Official Agriculture Chemists. 1955. Official methods of analysis. 8th ed Washington, D. C. Pages 564-568.

Bergen, P., G.H. Whitfield, and C.E. Lilly 1986. Effect of insecticides and herbicides on sugarbeet establishment, yield, and control of the sugarbeet root maggot. J. Am. Soc. Sugar Beet Technol. 23:162-173.

Cole, D.F. and A.G. Dexter. 1985. Effect of multiple pesticide treatments on sugarbeet yield and quality. J. Amer. Soc. Sugar Beet Technol. 23:109-115.

Schweizer, E.E. 1979. Weed control in sugarbeets *(Beta vulgaris)* with mixture of cycloate and ethofumesate. Weed Sci. 27:516-519.

Wedderburn, R.N., L.E. Jenkins, and E.E. Schweizer. 1973. Effects of combinations of liquid and granules formulations of disulfoton and cycloate on sugarbeets. Environ. Entomol. 2:915-917.

Wilson, R.G., J.A. Smith, and C.D. Yonts. 1990. Effect of seeding depth, herbicide, and variety on sugarbeet *(Beta vulgaris)* emergence, vigor, and yield. Weed Tech. 4:739-742.