Effect of Insecticide Placement on the Phytotoxicity of Planting Time Insecticides and Their Interaction with Herbicides[†]

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ABSTRACT

Experiments were conducted to determine the influence of insecticide placement on phytotoxicity to sugarbeet. A greenhouse study showed that post planting chlorpyrifos application did not damage sugarbeet as much as similar applications at planting. The lack of differences in sugarbeet injury between the placement of chlorpyrifos in the furrow (T-band) and on the surface indicates that surface applications can cause significant damage. In two field studies we found that insecticide placement was an important factor in determining the potential for insecticide phytotoxicity on sugarbeet. The greatest injury was obtained when chlorpyrifos, fonofos, and terbufos were placed behind the furrow openers and in front of the press wheel. This placement would be the most likely to result in closer association between the insecticide granules and the seed. Both the modified in-furrow chlorpyrifos treatment and the band in front of the press wheel resulted in substantial sugarbeet damage, even at the lower rates. Insecticide bands ahead of the planter unit resulted in intermediate damage. Band applying the insecticides to the rear of the press wheel resulted in the least phytotoxicity. Apparently, the sealing action of the press wheel reduces the contact with the seed and prevents the insecticide from mixing in the upper layers of the soil. Insecticide placement behind the press wheel provided the best protection from phytotoxicity; however, even this placement did not eliminate the potential for phytotoxicity.

Additional Key Words: Aldicarb, chlorpyrifos, cycloate, fonofos, terbufos, phytotoxicity, *Beta vulgaris*.

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Application of soil applied pesticides to sugarbeet (*Beta vulgaris* L.) for weed and insect control is a common practice. The objective of pesticide application is to control the yield reducing impact of the targeted pest. However, research has shown that herbicides (Schweizer, 1979; Wilson and Hein, 1991) and insecticides (Askew et al., 1973; Bergen et al., 1986; Bergen and Whitfield, 1986; Wilson and Hein, 1991) can have a significant negative impact on sugarbeet seedling establishment, vigor, and yield. In addition, Wilson and Hein (1991) found that herbicides and insecticides interact in some instances.

Two current trends, planting to final stand without thinning and increased plant populations, increase the potential impact of pesticide phytotoxicity. Even though the occurrence of such phytotoxicity is well documented, the sporadic nature of severe damage and the benefits derived from the application of both herbicides and insecticides on sugarbeet has allowed the phytotoxicity problem to persist. The occurrence of pesticide phytotoxicity has been blamed on such factors as soil texture, pH, organic matter; environmental conditions; inadequate or poor equipment calibration; or pesticide placement. The uncertainty about the causes of phytotoxicity to sugarbeet has contributed to its persistence.

Researchers have recognized that application method influences the extent of subsequent damage to sugarbeet. Allen et al. (1969) reported sugarbeet phytotoxicity from both organophosphates and carbamates and cautioned against placing fonofos in the seed furrow. Askew et al. (1973) noted increased damage to sugarbeet when soil insecticides were placed in direct contact with the seed. Bergen and Whitfield (1986) found banding improved stand when compared to an in-furrow treatment for some insecticides. But, the impact of insecticide placement on phytotoxicity is not completely understood. The manufacturer's label of some insecticides used for planting time application on sugarbeet cautions about avoiding granule contact with the seed; however, these labels also allow for placements that may result in seed contact. In a study of granular insecticide placement in corn with three planters, band application in front of the press wheel resulted in granule contact with the seed, particularly under moist soil conditions (Erbach and Tollefson 1983). These workers found that phytotoxicity problems in corn could be alleviated by placing the granules behind the planter press wheels. The objectives of our study were to determine the impact of insecticide placement and, to a limited extent, timing on the phytotoxicity to sugarbeet of insecticides applied with and without herbicides.

Materials and Methods

Experiment 1: A greenhouse study was conducted to determine the effect of chlorpyrifos placement near the seed, herbicide application, timing of the insecticide application, and temperature on seedling establishment and vigor. A factorial arrangement of two herbicide treatments and four insecticide timings was used, with two temperature regimes as the main plot treatments. The temperature regimes were: 1) plants held in a greenhouse at temperatures fluctuating between 16 and 24°C, and 2) plants held in a growth chamber with fluctuating temperatures for seven days. During these seven days plants were held at fluctuating temperatures of 10 to 16°C for three days, followed by three days of -1 to 10°C which included two hours at -1°C, and the final day at 10 to 16°C. The plants held in the growth chamber were then returned to the greenhouse and held with the other plants until evaluation. The herbicide treatments were cycloate (S-ethyl cyclohexylethyl carbamothioate) applied at 2.8 kg active ingredient ha^{-1} and an untreated control. Each herbicide treatment was applied in combination with each of four insecticide placements or timings, each of which included a 12.7 cm band application of granular chlorpyrifos [15% active ingredient; O,O-diethyl O-(3,5,6-trichloro-2-pyridinyl) phosphorothioate] at a rate of 83 g/100 m. The four insecticide applications were made to an open furrow (T-band) at planting, a closed furrow at planting, just after cotyledon emergence, and at the two-true-leaf stage. Each of these treatments was applied in a 24 x 50 x 7 cm flat filled with fine sandy loam soil. Split plots within each flat included an insecticide treated and untreated row.

The study was replicated six times with two replicates planted each week for three weeks. This stagger allowed use of the growth chamber for establishing the temperature regimes. Cycloate was applied broadcast then incorporated into the upper 4 to 5 cm of soil. Furrows were made in each flat for planting two rows approximately 18 cm apart. 'Hilleshog Mono-Hy 55' Sugarbeet was planted at 2.5 cm intervals in the furrows. All furrows were covered and firmed immediately, except the T-band treatments which were covered after the insecticide was applied. Insecticides were applied by mixing 0.436 g of chlorpyrifos granules with 1.5 g of blank granules, to facilitate the uniform distribution of the active granules. All treatments were incorporated lightly by roughening the soil surface.

At the four-true-leaf stage, plants were counted to determine emergence, plant heights were measured, and the plants were harvested, dried, and dry weights determined. Data were analyzed by analysis of variance (SAS Institute, 1988).

Experiment 2: The impact of chlorpyrifos placement was evaluated in split-plot field experiments in 1991 and 1992. The main plots were 28 rows wide and 15 m long and arranged in a randomized complete block design with four replicates. The two main plot treatments were cycloate herbicide applied before planting at 2.8 kg active ingredient ha^{-1} and incorporated to a depth of 2 to 5 cm and a herbicide untreated control. Split-plot treatments within the main plots were a factorial arrangement of treatments with six insecticide placements, each at two chlorpyrifos rates. Granular chlorpyrifos (15% active ingredient) was applied: 1) in a 12.7 cm band in front of the planter, 2) in a 12.7 cm band in front of the planter with rotary hoe incorporation to a 5-cm depth, 3) in a 12.7-cm band behind the furrow openers and in front of the press wheel, 4) in a narrow band behind the furrow openers and just in front of the press wheels where the insecticide was dropped out of an open tube directly over the row (modified in-furrow), and 5) in a 12.7 cm band behind the press wheel of the planter. A sixth chlorpyrifos treatment was the application of liquid chlorpyrifos in a 12.7 cm band over the sugarbeet row at the cotyledon stage. All six treatments were applied at two rates including the maximum registered rate for sugarbeet root maggot control (83 g/100 m of row) and at twice this rate (166 g/100 m of row). The higher rate was used to increase the potential for phytotoxicity so that the impact of placement could be more readily determined. Two insecticide untreated controls were included with one receiving the pre-plant rotary hoeing as applied in treatment number 2 above. Split-plot treatments were randomized within the main plots and were two rows wide and 15 m long.

Cycloate was broadcast applied on 16 April, 1991 and 6 April, 1992 with a tractor-mounted sprayer calibrated to deliver 200 L ha^{-1}. Plots were planted on 17 April, 1991, and 14 April, 1992. In both years, 'Hilleshog Mono-Hy 55' sugarbeet was planted 2.5 cm deep with a John Deere 71 unit planter with 56 cm row spacing and 7.6 cm seed spacing.

All plots were marked with a pass of the planter without planting. After marking with the planter, insecticide treatments placed ahead of the planter were applied over the row with a bicycle-type push applicator equipped with a Noble metering unit (Remcor, Inc., 504 Deny, Box 717, Howe, TX 75909). The insecticide treated and untreated rotary-hoe plots were then incorporated with a hand-held rotary hoe. Marked rows were then planted and the modified in-furrow and band ahead of the press wheel placements were applied. Noble metering units mounted on the planter were used to apply these insecticide treatments. The band behind the press wheels was applied with the bicycle-type push applicator immediately after planting had been completed. All treatments were incorporated with straight drag chains after planting. Insecticide metering units were calibrated at field planting speed. The cotyledon chlorpyrifos application was made with a backpack sprayer calibrated to deliver 187 L ha^{-1}.

All plots were replicated four times. The 1991 study was conducted at Scottsbluff, NE on a Tripp fine sandy loam soil with cation exchange capacity of 5.8 meg/100 g, organic matter 0.8% and pH 8.3. The 1992 study was conducted near Mitchell, NE on a Tripp fine sandy loam soil with organic matter 0.8% and pH 8.0. The plot area was plowed and packed prior to planting. In 1991, a soil fumigant (Telone II) was applied at plowing to control sugarbeet root knot nematode in the entire plot area. All plots were kept weed free with hand weeding and cultivation and were irrigated as needed throughout the season. Low infestations of sugarbeet root maggot developed in the plots both years. Other insects were not a problem in either year of this experiment.

Experiment 3: An additional study was done in both 1991 and 1992 to evaluate the influence of placement on the phytotoxicity of four other planting-time insecticides. The experimental design was a randomized complete block design with four replicates and a factorial arrangement of treatments. Aldicarb at 2.2 and 4.5 kg active ingredient ha^{-1} [15% granular, 2-methyl-2-(methylthio)propionaldehyde O-methylcarbamoyl) oxime]; fonofos at 1.6 and 3.3 kg active ingredient ha^{-1} [20% granular, O— ethyl-S-phenylethylphosphonodithioate]; and terbufos 15G [15% granular, S-(((1,1-dimethylethyl)thio)methyl) O,O-diethyl phosporodithioate] and terbufos 20CR (20% granular) at 2.0 and 4.0 kg active ingredient ha^{-1} were applied in three placements: 1) a 12.7 cm band in front of the planter with rotary hoe incorporation, 2) a 12.7 cm band between the furrow openers and the press wheel, and 3) a 12.7cm band behind the press wheel. Application techniques, plot locations, soil type, plot preparation, and planting dates were the same as in Experiment 2.

In both field studies, sugarbeet stand was monitored weekly beginning shortly after emergence by counting all plants in each plot. Stand counts were begun in mid-May and continued until early June when stand establishment was completed. Visual estimates of sugarbeet injury (0 = no injury and 100 = completely killed) were recorded in late May or early June each year. Sugarbeet plants were topped, lifted, and weighed early in October with a mechanical two-row harvester. The entire plot, two rows by 15 m, was harvested, and a subsample (ca. 12 kg) from each plot was washed, weighed, and analyzed for sucrose content by Western Sugar Company with the method described by the Association of Official Agriculture Chemists (1955).

Data from both years were combined, and a pooled analysis was done for each experiment. The variables examined were final stand counts taken in early June, visual injury estimates, sugarbeet root yield, percent sugar, and sugar yield. Data for these variables, except visual injury estimates, were compared to the appropriate untreated check and expressed as percent reduction from the check. The rotary-hoed checks were used to estimate reductions for the rotary-hoed treatments. Analyses indicated that all the percent reduction variables in each experiment were normally distributed (Univariate procedures, SAS Institute 1988) and analysis of variance was appropriate. The visual injury data were not normally distributed and were square-root transformed to obtain a normally distributed variable.

Results and Discussion

Experiment 1: Cycloate application in the greenhouse experiment significantly reduced plant height and dry weight of sugarbeet (Table 1). The effect of temperature was significant for plant height, with the higher temperature regime resulting in taller plants. The time of chlorpyrifos application resulted in significant differences for each variable measured. The orthogonal contrasts indicated that these differences were the result of a significant contrast between the at-plant and the post-applied treatments for each variable. No interactions occurred between these main effects.

The effects of chlorpyrifos were significant for each of the three variables measured, with the untreated rows having more, taller, and heavier plants (Table 1). The only significant interactions were between the insecticide treatments and time of application. This interaction was significant for each of the three variables (Figure 1). Stand, height, and weight were not affected by the time of application for the untreated plants. However, all three variables were reduced for the at-plant treatments when compared to the postemergence applications.

In this experiment, time of application was a determining factor in pesticide phytotoxicity. Both at-plant chlorpyrifos band applications reduced stand and vigor of sugarbeet; however, the surface band and the T-band were similar. This indicates that seed contact with the insecticide is not the only causal factor in phytotoxicity. The impact of the surface band would occur only if the sugarbeet seedling contacted the insecticide as it grew through the insecticide zone in the soil. Chlorpyrifos is very insoluble and would remain in a narrow layer in the soil near the surface (Racke, 1993). This

Table 1. Summary of greenhouse experiment analysis of variance for sugarbeet stand, plant height, and dry weight.

Effects	d.f.	Stand		Plant Height		Dry Weight	
		PrμF	(plants/row)	PrμF	(cm)	PrμF	(g)
Herbicide	1	0.80	14.3 vs. 14.2	**	13.9 vs. 16.4	**	4.4 vs. 5.9
cycloate vs. untreated							
Temperature	1	0.57	14.1 vs. 14.4	**	15.9 vs. 14.3	0.17	5.4 vs. 4.9
high vs. low							
Time of chlorpyrifos							
application	3	**		**		**	
at plant vs. post	(1)	**	13.2 vs. 15.4	**	14.5 vs. 15.8	**	4.6 vs. 5.6
band vs. T-band	(1)	0.79	13.1 vs. 13.2	0.15	14.7 vs. 14.3	0.60	4.7 vs. 4.6
cotyledon vs. 1st leaf	(1)	0.67	15.5 vs. 15.2	0.50	15.6 vs. 15.9	0.20	5.4 vs. 5.9
Chlorpyrifos							
treated vs. untreated	1	**	13.3 vs. 15.2	**	13.7 vs. 16.5	**	4.1 vs. 6.2

* , ** Significant at 0.05 and 0.01 probability levels, respectively.

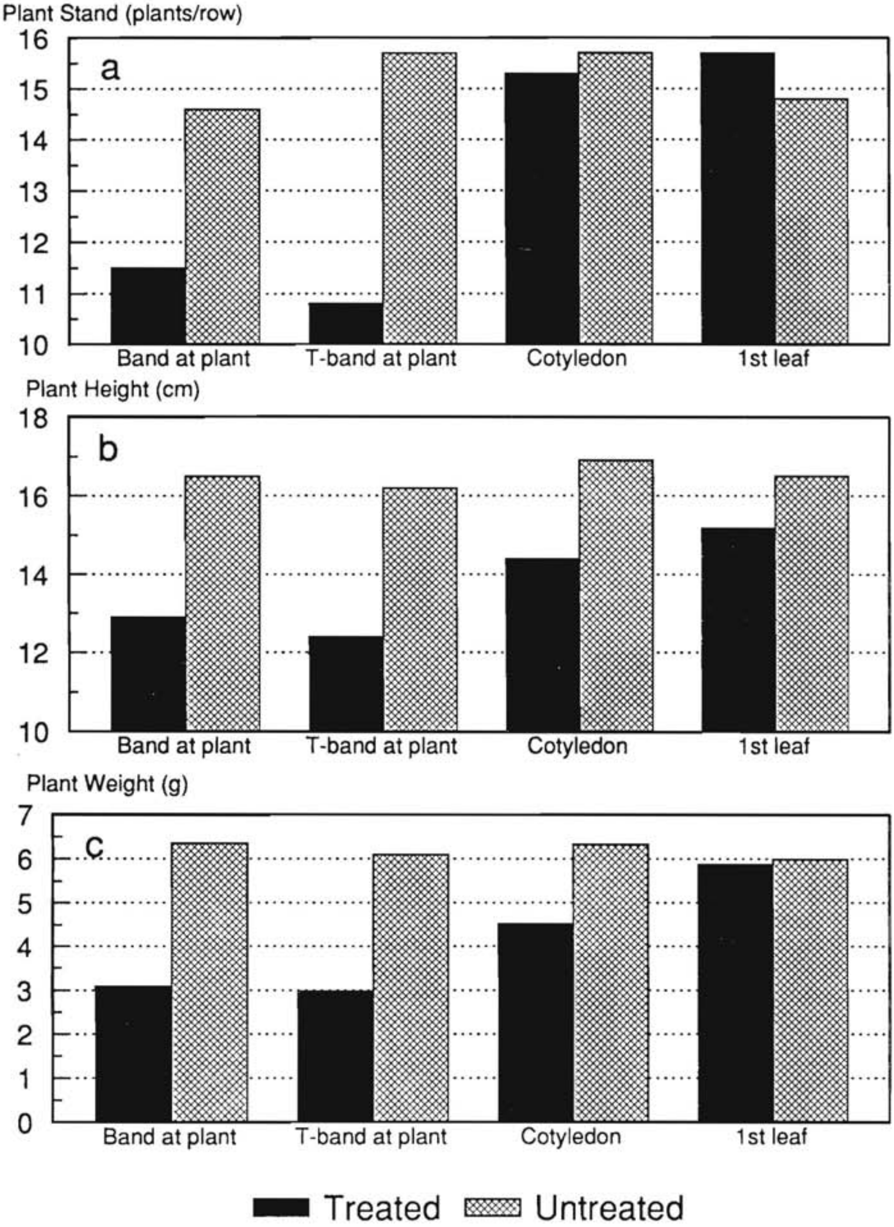

Figure 1. Plant stand (plants per 50 cm row), height, and weight of sugarbeets planted in the greenhouse and treated with four chlorpyrifos placements or timings (LSD = 2.09 (a), 1.77 (b), and 1.72 (c)).

may explain why phytotoxicity has been reported where direct seed contact with the insecticide is unlikely or impossible.

Experiment 2: The analyses of variance for Experiment 2 are shown in Table 2. There were no differences between years for any variable, and no significant interactions between any of the factors and year for any variable. Because no interactions with year occurred, the combined analyses are reported. Stand reduction in this study averaged 23.4% across both years. Differences in the effects of cycloate were not significant; however, cycloate treatment tended to lower sugarbeet stand. The effects of chlorpyrifos placement and rate were both highly significant. Partitioning of the placement sums of squares resulted in four of the five orthogonal comparisons being significant. Planting-time chlorpyrifos treatments resulted in significantly more stand loss than the post applied treatments. Placing the insecticide behind or in front of the planter unit improved stand compared to placements between the furrow openers and the press wheel (middle). The band placement in front of the press wheel resulted in less damage than the modified in-furrow placement, but still averaged 35.1% stand reduction. A comparison of the front and rear placements showed that the rear placement resulted in the least damage. The rotary-hoe incorporation of the front placement resulted in more damage than the non-incorporated treatment, but this was only approaching significance at P = 0.09. The effect of increasing chlorpyrifos rate resulted in a significant doubling of sugarbeet stand reduction. Interactions between the factors in the analysis were not significant.

The results from the visual injury data support the stand reduction data. The effects of herbicides, placement, and rate were all highly significant (Table 2). Cycloate increased sugarbeet injury from 5% to 14%, and doubling the chlorpyrifos rate increased the sugarbeet injury from 6.6% to 11.8%. Planting-time chlorpyrifos applications resulted in more sugarbeet injury than the post application. The greatest sugarbeet injury was seen when chlorpyrifos was applied between the furrow opener and the press wheel. Insecticide placement in the front of the planter resulted in more sugarbeet injury than placement to the rear. No interactions between any of the factors were significant in the visual injury analysis.

Analysis of the data for the reduction in sugar percentage showed few differences. The only main effect that was significant (P = 0.02) was rate, with the lower insecticide rates averaging 0.65% reduction in sugar percentage and the higher rate averaging 0.82% increase in sugar percentage. It is uncertain why the higher rate resulted in an average increase in sugar percentage, but this represents only an increase in sugar percentage from 16.52% to 16.75%.

Table 2. Summary of Experiment 2 analysis of variance for reduction in sugarbeet stand, vigor, and sugar yield, 1991 and 1992 combined analysis.

Effects	d.f.	% Stand Reduction		% Visual Injury		% Reduction in Sugar Yield	
		PrμF		PrμF		PrμF	
Year (1991 vs. 1992)	1	0.77	22.1 vs. 24.5	0.85	8.67 vs. 9.43	0.48	20.6 vs. 15.4
Herbicide							
untreated vs. cycloate	1	0.11	10.0 vs. 36.6	**	5.05 vs. 14.19	0.15	14.5 vs. 21.5
Chlorpyrifos placement	5	**		**		**	
planting time vs. post	(1)	**	29.2 vs. -6.4	**	9.86 vs. 5.43	**	20.7 vs. 4.7
middle vs. front and rear	(1)	**	41.8 vs. 20.9	**	14.82 vs. 7.13	**	33. 8 vs. 11.9
middle: band vs. modified in furrow	(1)	*	35.1 vs. 48.4	0.40	13.62 vs. 16.09	**	28.0 vs. 39.7
front vs. rear	(1)	**	26.0 vs. 10.7	*	8.29 vs. 4.99	0.11	13.9 vs. 7.8
front: incorporated vs. non-incorporated	(1)	0.09	31.0 vs. 21.0	0.44	9.19 vs. 7.51	0.71	14.7 vs. 13.1
Rate (low vs. high)	1	**	15.1 vs. 31.5	**	6.63 vs. 11.83	**	9.6 vs. 26.4

* , ** Significant at 0.05 and 0.01 probability levels, respectively.

Sugarbeet root yield reduction was similar to the reduction in total sugar yield; therefore, only the results for percent reduction in sugar yield are presented in Table 2. Only the effects of placement and rate were significant for this variable. The higher insecticide rates resulted in a 26.4% sugar yield reduction while the lower rates reduced yield 9.6%. The orthogonal comparisons of the placement treatments for sugar yield support the results obtained from stand reduction and sugarbeet injury. The least reduction in sugar yield was obtained with post-applied and the planting-time placement to the rear of the planter. Planting-time applications of chlorpyrifos yielded significantly less sugar than the post treatments, and the middle treatments resulted in the greatest sugar yield reduction with the modified in-furrow placement showing the greatest sugar yield reduction of all the treatments. Sugar yields of the front incorporated chlorpyrifos and non-incorporated treatments and the rear placement were not different, although the rear placement resulted in a numerically lower yield reduction. No significant interactions were found between the main factors for sugar yield reduction.

Experiment 3: All of the main effects were significant for sugarbeet stand reduction, but no interactions were significant (Table 3). Sugarbeet stand reduction was different in the two years of the study, with 1991 and 1992 averaging 31.5 and 17.9% stand loss, respectively. In addition, the effects of insecticides, placement, and rate all were significant. Orthogonal comparisons showed that the organophosphate insecticides fonofos and terbufos reduced sugarbeet stand more than aldicarb. Fonofos caused more sugarbeet stand reduction than terbufos. The two terbufos formulations caused similar sugarbeet stand reduction. These results are similar to those of Wilson and Hein (1991). Orthogonal comparisons between insecticide placements showed that the middle placement between the furrow openers and the press wheel (30.7%) was significantly worse than the other two placements. However, this difference was the result of the low amount of sugarbeet damage from the rear insecticide placement (13.5%), while the placement in front of the planter unit was similar to the middle placement (30.0%). The higher insecticide rate resulted in a significantly greater stand reduction.

As with stand reduction, all the main effects of sugarbeet injury were significant with no significant interactions (Table 3). Sugarbeet injury was significantly lower in 1992 with about half of the damage observed in 1991. The comparisons of insecticide effects again showed the differences between the organophosphates and aldicarb and between terbufos and fonofos. The differences between the two

Table 3. Summary of Experiment 3 analysis of variance for reduction in sugarbeet stand, vigor, and sugar yield, 1991 and 1992 combined analysis.

Effects	d.f.	% Stand Reduction		% Visual Injury		% Reduction in Sugar Yield	
		PrμF		PrμF		PrμF	
Year (1991 vs. 1992)	1	*	31.5 vs. 17.9	*	11.82 vs. 5.46	0.16	15.4 vs. -6.3
Insecticide	3	**		**		**	
organophosphates vs. aldicarb	(1)	**	30.8 vs. 6.3	**	12.22 vs. 1.37	**	11.6 vs. -16.9
terbufos vs. fonofos	(1)	**	23.7 vs. 45.1	**	9.94 vs. 16.79	**	6.3 vs. 22.3
terbufos: 15% vs. 20%	(1)	0.30	26.0 vs. 21.5	0.10	11.67 vs. 8.21	0.78	5.6 vs. 7.0
Placement	2	**		**		**	
Middle vs. front, rear	(1)	**	30.7 vs. 21.7	**	13.51 vs. 6.38	0.06	9.4 vs. 2.1
Front vs. rear	(1)	**	30.0 vs. 13.5	**	8.44 vs. 4.33	**	8.1 vs. -4.0
Rate (low vs. high)	1	**	18.4 vs. 31.0	**	6.70 vs. 10.15	*	0.2 vs. 8.8

* , ** Significant at 0.05 and 0.01 probability levels, respectively.

two formulations of terbufos were not significant, but were approaching significance with P = 0.10. Insecticide placement comparisons showed that the middle placement caused the greatest vigor loss and the rear placement was the safest.

No differences were noted for the reduction in percent sugar. The reduction in sugar yield, due to root yield differences, supported the effects seen for stand reduction and vigor loss with the main effects of insecticides, placement, and rate being significant. The effects of insecticides resulted in two significant comparisons with aldicarb providing greater sugar yields than the organophosphates and fonofos resulting in a greater yield reduction than terbufos (Table 3). The increased yields from aldicarb may have been due to a combination of factors. Little sugarbeet root maggot fly activity was seen near this field and no root damage ratings were done in the plots. However, a limited amount of root scarring was observed at harvest. This may have impacted the yield increase by aldicarb, but the other treatments should have provided comparable control of the root maggot.

Much of this yield increase may have been due to control of sugarbeet nematode (the sugarbeet cyst nematode, *Heterodera schachtii* Schmidt, and the false root-knot nematode, *Nacobbus aberrans* Thorne and Allen) that are common in the area. Of the chemicals used in the study, aldicarb and terbufos have nematicidal activity, but aldicarb would provide better nematode control, especially for *H. schachtii* (Griffin, 1988). Sugar yield was greater when insecticides were placed behind the planter versus in front of the planter. The year by chemical interaction was significant (P = 0.02). This interaction was the result of the yield reductions decreasing substantially from 1991 to 1992 for the three organophosphates. Yields dropped an average of 28% overall, while the yield reductions for aldicarb declined 2%.

The occurrence of pesticide phytotoxicity in the field can be quite variable. In our studies, sugarbeet damage varied nearly 50• between the two years. Both field studies showed that insecticide placement is a very important factor in determining the potential for insecticide phytotoxicity. The treatments resulting in the most sugarbeet injury were those that were placed behind the furrow openers and in front of the press wheel. These treatments would be the most likely to result in closer association between the insecticide and the seed.

From Experiment 1, direct contact with the seed is not necessary for damage to occur. Both the modified in-furrow treatment and the band in front of the press wheel resulted in significant sugarbeet damage even at the lower insecticide rates. The level of sugarbeet damage from several of these treatments is important because some of these are labeled placements for the insecticides tested. In both years, soils were dry at the time of planting, and as the planter passed, soil flowed into the furrow and closed the opening left by the planter. It is unlikely that direct contact between the seed and the insecticide would have occurred to a great extent for the middle placements. However, the insecticide for these middle placements would have been mixed with the upper layers of soil. The more severe damage resulting from the modified in-furrow placement could be the result of a greater concentration of insecticide directly over the seed. The bands ahead of the planter unit resulted in intermediate damage. The action of the planter unit as it planted into the insecticide band mixed the insecticide into and above the seed zone.

The best treatment in reducing the amount of insecticide phytotoxicity was the band to the rear of the press wheel. The sealing action of the press wheel eliminates insecticide contact with the seed and prevents the insecticide from mixing in the upper layers of the soil.

Placement behind the press wheel provided the best protection from phytotoxicity; however, even this placement did not eliminate the potential for phytotoxicity. For the organophosphates tested in Experiment 3, the low (registered) rates placed behind the press wheel resulted in stand reductions in 1991 of 13% for terbufos 20CR, 22% for fonofos and 25% for terbufos 15G. Placement to the rear of the planter has not been found to affect sugarbeet root maggot control (unpublished data, G. L. H.). Several considerations need to be made in using a soil insecticide on sugarbeets. Some of these include the timing of the application, the need for the planting-time treatment, the rate, the herbicide program, chemical selection, calibration, and placement.

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