# Insecticide Placement Interactions with Preplant Herbicides in Sugarbeets

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## ABSTRACT

**Pesticides are required to obtain an adequate stand of weed-free sugarbeets, but they often cause sugarbeet injury and/or stand loss. The objective of this research was to evaluate the interactive effects of insecticides, insecticide placement, and preplant herbicides on sugarbeet stand establishment and injury. No interactions or insecticide effects were found in three experiments when insecticides and preplant herbicides were band-applied and rotary incorporated ahead of the sugarbeet planter. Severe injury (25 percent) and stand reductions (76 percent) resulted with fonofos applied prior to the planter press wheel with all herbicide treatments, as compared to applying fonofos prior to the rotary incorporator or behind the planter press wheel. Results from a study at four locations with three insecticide placements, four insecticide treatments and four herbicide treatments indicated an insecticide placement x herbicide interaction for sugarbeet injury, but the differences were small. The largest sugarbeet population differences were due to preplant herbicide treatment. It appears that if insecticides are incorporated ahead of the planter or behind the planter press wheel, there was not much additional sugarbeet stand loss or injury than from preplant herbicides applied alone.**

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

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Planting sugarbeets *(Beta vulgaris* L.) to stand and sequential application of preplant and postemergence herbicides is the most economical management practice for obtaining an adequate stand of weed free sugarbeets (Miller, et al., 1992). The average benefit of planting to stand versus overseeding and thinning was $47/A at four locations and the average benefit of no labor versus full labor without herbicides was $167/A at two locations.

Yields of sugarbeet planted to stand are comparable with yields of sugarbeet that is overseeded and thinned, if the initial plant populations are in the range of 25 to 40 thousand plants/A (Fornstrom, 1980). Studies have been conducted to evaluate the effect of herbicides and varieties on sugarbeet stand establishment (Fornstrom and Miller, 1990). Weed control with sequential preplant and postemergence herbicides was very good; however, sugarbeet stands were less with sequential herbicide treatments. Cycloate [S-ethyl cyclohexylethylcarbamothioate] plus ethofumesate [(+)-2-ethoxy-2,3-dihydro-3,3-dimethyl-5-benzofuranyl methanesulfonate] resulted in the largest stand reductions. Sugarbeet stands also varied up to 30 percent based on variety, but no herbicide X variety interactions were observed. In studies with herbicides, insecticides, and varieties, no consistent effects or interactions on sugarbeet quality, at harvest or after storage, were noted when EPTC [s-ethyl dipropylcarbamothioate], a preplant herbicide; aldicarb [2-methyl-2-(methylthio)propionaldehyde O-methylcarbamoyl) oxime], an insecticide; or desmedipham [ethyl (3-(((phenylamino)carbonyl)oxy)phenyl) carbamate], a postemergence herbicide, were applied to three varieties (Cole and Dexter, 1985). Insecticides, which may be needed to protect sugarbeets from some insects, generally do not cause stand loss when used by themselves; however, Bergen, et al. (1986) noted that when insecticides were applied with preplant herbicides and when placed next to the seed, up to 15 percent sugarbeet stand loss could occur. Wilson and Hein (1991) reported that cycloate was more damaging than ethofumesate or diethatyl [N-(choroacetyl)-N-(2,6-diethylphenyl)glycine], and that the organophosphate insecticides chlorpyrifos [O,O-diethyl O-(3,5,6-trichloro-2-pyridinyl) phosporothioate], fonofos [O-ethyl-S-phenylethylphosphonodithioate] and terbufos [S-(((1,1-dimethylethyl)thio)methyl) O,O-diethylphosphorodithioate]) caused more injury than the carbamate insecticides aldicarb and carbofuran [2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate]), but there was an interaction in only one of three years.

The objective of this research was to evaluate the interactive effects of insecticides, insecticide placement, and preplant incorporated herbicides on sugarbeet stand establishment and injury. The research was initiated in 1990 to evaluate insecticide x herbicide interactions and expanded in 1991 to evaluate the effect of insecticide placement. The research will be presented as three studies: herbicide-insecticide interactions (three location-years of data); herbicide-fonofos placement interactions (one location-year); and insecticide incorporation-herbicide interactions (four location-years).

## MATERIALS AND METHODS

The research trials were conducted at the Powell or Torrington, Wyoming, Research and Extension Centers. At Powell, the soil was a Garland clay loam (fine, mixed Mesic Typic Haplargid; 40% sand, 29% silt and 31% clay with 1.4% organic matter and pH 7.6). Sugarbeets (var. MonoHy R2) were seeded with 22-inch row spacing at the rate of 56,000 seeds/A and plots were furrow irrigated. At Torrington, the soil was a Bayard sandy loam (coarse, loamy mixed Mesic Torriorthentic Haplustoll; 78% sand, 13% silt and 9% clay with 1.4% organic matter and pH 7.6). Sugarbeets (var. Monohikari) were seeded with 30-inch row spacing at the rate of 68,000 seeds/A and plots were sprinkler irrigated. All preplant herbicides were applied in a 7-inch band with a planter-mounted sprayer delivering 40 gpa at 26 psi (Teejet 80015 spray tip) and incorporated immediately with a rotary-power incorporator operating at a depth of 1 inch. Plots were cultivated and hand weeded after initital plant counts to maintain a weed free condition throughout the growing season.

An analysis of variance (ANOV) was performed on all data and means were separated by Fischer's protected LSD at the 0.05 probability level (Snedecor and Cochran, 1967).

**Herbicide-insecticide interactions.** Three experiments were conducted to compare the interaction of preplant incorporated herbicides with insecticides, at Powell in 1990 and at Torrington in 1990 and 1991. The experimental design was a split plot with four replications. Insecticide treatments included chlorpyrifos, aldicarb, terbufos and a non-insecticide-treated check.

Herbicide treatments included cycloate, ethofumesate, cycloate plus ethofumesate, diethatyl, ethofumesate plus diethatyl and a non-herbicide-treated check. Insecticides were applied immediately ahead of the power incorporator in a 7-inch band and incorporated with the preplant herbicides to a depth of 1 inch.

Sugarbeet populations were determined by counting two ten ft areas in each plot. Sugarbeet yields were determined by hand harvesting a random ten ft length of row in each plot. Sucrose percentage and tare were determined by Holly Sugar Corporation or The Western Sugar Company.

**Herbicide-fonofos placement interactions.** A study was conducted at Torrington in 1991 to evaluate the influence of fonofos placement with preplant incorporated herbicide treatments on sugarbeet injury and stand establishment.

Four replications were arranged in a split plot experimental design. Fonofos treatments were applied with a granular applicator and 7-inch band spreader to place the insecticide before the rotary incorporator, before the planter press wheel or after the planter press wheel. A drag chain mounted behind the press wheel shallowly incorporated the before and after press wheel insecticide treatments. Herbicide treatments included cycloate, cycloate plus ethofumesate, ethofumesate plus diethatyl and a non-herbicide-treated check.

Evaluations included sugarbeet stand counts, visual crop injury ratings (0 to 100 percent, with 0 = no injury and 100 = complete kill), and sugarbeet yield.

**Insecticide incorporation-herbicide interactions.** Four experiments were conducted in 1992 and 1993, two each at Torrington and Powell, to evaluate the interactive effects of insecticide placement, insecticide and preplant herbicide on sugarbeet stand establishment and injury. Four replications were arranged in a split-split plot design. Insecticide treatments were applied before the power incorporator, before the planter press wheel, and after the planter press wheel, as in the herbicide-fonofos placement study. Insecticide treatments included chlorpyrifos, carbofuran, fonofos, aldicarb, terbufos, and a non-insecticide-treated check in 1992; and chlorpyrifos, carbofuran, fonofos, and a non-insecticide-treated check in 1993. Herbicide treatments included cycloate, ethofumesate, cycloate plus ethofumesate, diethatyl, ethofumesate plus diethatyl, and a non-herbicide-treated check in 1992; and cycloate, ethofumesate, cycloate plus ethofumesate, and a non-herbicide-treated check in 1993. Evaluations included sugarbeet stand counts and injury ratings.

## RESULTS

**Herbicide-insecticide interactions.** Sugarbeet populations in response to insecticide and herbicide treatments for the three experiments conducted in this study are presented in Table 1. There were no significant differences in sugarbeet populations in response to insecticide application and no interactions between insecticide and herbicide treatment. There was a significant difference in sugarbeet population in response to herbicide treatment for two of the three experiments. Diethatyl or cycloate plus ethofumesate reduced sugarbeet stands up to 14 percent compared to the stand for the non-herbicide-treated check, but not to a point that caused a yield decrease (data not shown).

**Herbicide-fonofos placement interactions.** Sugarbeet injury, population, and yield in response to fonofos placement and herbicide treatment are shown in Table 2. Sugarbeet injury (25 percent) and stand reduction (76 percent) were severe when fonofos was placed before the planter press wheel. In addition, sugarbeet injury and stand reduction were also increased for all three herbicide treatments. Cycloate plus ethofumesate caused the most injury (19 percent) and stand reduction (36 percent). Sugarbeet root yield (Y, T/A) was regressed against sugarbeet stand at harvest (P, 1000 plants/A) and the data best fit a non-linear model, $Y = 0.2 + 2.05\ P - 0.0343\ P^2$, $r^2 = 0.94$ (Weisherg, 1980). Injury and stand reduction were probably related to environment. Growing degree day heat units (40° F base temperature, as used by Yonts et al., 1983) and

**Table 1.** Initial sugarbeet population in response to insecticide or herbicide treatment. Powell Research and Extension Center, 1990 (P90) and Torrington Research and Extension Center, 1990 and 1991 (T90 and T91).

| Comparison | Rate | Sugarbeet Population | | |
|---|---|---|---|---|
| | | P90 | T90 | T91 |
| | | 1000 pl/A | | |
| Insecticide: | (oz/1000 ft) | | | |
| none | —— | 33.1 | 45.2 | 30.0 |
| chlorpyrifos | 9 | 32.7 | 41.2 | 28.1 |
| aldicarb | 22 | 30.4 | 43.7 | 30.2 |
| turbufos | 8 | 32.8 | 43.0 | 30.2 |
| LSD (0.05) | | NS | NS | NS |
| Herbicide: | (lb ai/A)[†] | | | |
| none | —— | 33.9 | 45.3 | 31.5 |
| cycloate | 2.5/3.0 | 31.8 | 42.8 | 33.2 |
| ethofumesate | 2.0/3.0 | 30.5 | 45.7 | 29.1 |
| cycl. + etho. | 1.5 + 1.5/2.0 + 2.0 | 32.5 | 42.5 | 28.3 |
| diethatyl | 3.0/4.5 | 32.3 | 39.7 | 27.3 |
| etho. + diet. | 1.5 + 1.5/2.0 + 2.0 | 32.6 | 43.5 | 28.5 |
| LSD (0.05) | | NS | 3.9 | 3.6 |
| Mean | | 31.7 | 43.2 | 29.6 |

[†] Herbicide rates are for Torrington/Powell

precipitation for the period April 19 through May 30 (approximately equal to the period from planting through injury evaluation) are shown in Table 3. For this period, 1991 was extremely cool and wet at Torrington, with heat unit accumulation equal to 62 percent of the 30 year mean value (Pochop, 1977) and precipitaion equal to 166 percent of the 30 year mean value (Martner, 1986).

**Table 2.** Sugarbeet response to fonofos placement and herbicide treatment. Torrington Research and Extension Center 1991.

| Comparison | Rate | Sugarbeets | | | | |
|---|---|---|---|---|---|---|
| | | Injury | Stand Initial | Stand Harvest | Yield | Sucrose |
| | | % | 1000 pl/A | 1000 pl/A | T/A | % |
| Insecticide-placement: | (oz/1000 ft) | | | | | |
| none | — | 7 | 27.0 | 25.0 | 29.7 | 15.3 |
| fonofos incorporated | 5 | 9 | 24.7 | 20.6 | 27.2 | 14.7 |
| fonofos before press wheel | 5 | 25 | 6.4 | 6.6 | 12.5 | 14.9 |
| fonofos after press wheel | 5 | 8 | 24.7 | 20.8 | 26.9 | 14.8 |
| LSD (0.05) | | 4 | 6.0 | 9.8 | 7.4 | NS |
| Herbicide: | (lb ai/A) | | | | | |
| none | — | 4 | 25.7 | 22.9 | 26.8 | 15.3 |
| cycloate | 2.5 | 11 | 21.3 | 19.2 | 26.3 | 14.9 |
| cycloate + ethofumesate | 1.5+1.5 | 19 | 16.4 | 14.7 | 20.5 | 14.5 |
| ethofumesate + diethatyl | 1.5+1.5 | 14 | 19.4 | 16.3 | 22.7 | 14.9 |
| LSD (0.05) | | 2 | 3.9 | 2.6 | 4.8 | NS |
| Mean | | 12 | 20.7 | 18.3 | 24.1 | 14.9 |

**Table 3.** Comparison of growing degree day heat unit accumulation (40° F base temperature) and precipitation received during the emergence period (April 19-May 30), Powell and Torrington Research and Extension Centers.

| Year | Heat Units | | Precipitation | |
|---|---|---|---|---|
| | Powell | Torrington | Powell | Torrington |
| | degree days | | inches | |
| 1990 | 459 | 431 | 2.01 | 2.01 |
| 1991 | 445 | 378 | 0.78 | 5.22 |
| 1992 | 682 | 729 | 1.46 | 1.34 |
| 1993 | 566 | 623 | 1.47 | 0.57 |
| 30-year mean† | 572 | 608 | 1.36 | 3.15 |

† 30-year mean heat units from Pochop, 1977, and 30-year mean precipitation from Martner, 1986.

**Insecticide incorporation-herbicide interactions.** Initial sugarbeet populations in response to insecticide placement, insecticide treatment, or herbicide treatment are shown in Table 4. Insecticide placement significantly influenced sugarbeet population in only one of the four experiments.

Insecticide treatment did not significantly reduce sugarbeet population in any of the experiments. Herbicide treatment influenced sugarbeet population in three of the four experiments. The most severe stand loss due to herbicide treatment was at Torrington in 1993 where cyloate plus ethofumesate, cycloate, or ethofumesate reduced stands 46, 41 and 19 percent, respectively, when compared to the non-herbicide-treated check. These stand reductions were probably related to environment, although heat unit accumulation was near average and precipitation was low (Table 3). Minimum temperatures for four days immediately prior to planting and for eight of the first nineteen days after planting were below freezing. Sugarbeet injury was primarily influenced by herbicide treatment (Table 5) with no significant differences due to insecticide or insecticide placement (data not shown). The greatest sugarbeet injury occurred with cycloate plus ethofumesate (7.4 percent average injury) or ethofumesate alone (5.1 percent average injury). A significant sugarbeet injury interaction occurred between insecticide placement and herbicide treatment in the 1992 experiments (Table 5), but no consistent interactions were noted when all four experiments were considered.

## DISCUSSION

Most of the results of these studies indicated that sugarbeet response was not influenced by insecticide placement, insecticide treatment, herbicide treatment, or their interactions. The one exception was the case at Torrington for 1991, when the results were devastating. In this experiment, fonofos placed before the press wheel resulted in a sugarbeet yield of 12.5 T/A as compared to the non-insecticide-treated check yield of 29.7 T/A.

Incorporation of fonofos or placement of fonofos after the press wheel did not significantly reduce yields. Apparently, climatic conditions, soil conditions, insecticide treatment and placement as well as herbicide treatment all interacted to produce this effect on the sugarbeets in this one experiment, as the results were not duplicated in four succeeding trials. In general, it appears that if insecticides are incorporated ahead of the planter or behind the planter press wheel, i.e., isolated from the sugarbeet seed, there was very little additional sugarbeet stand loss or injury from that observed with the preplant herbicides applied alone.

**Table 4.** Initial sugarbeet population in response to insecticide placement, insecticide treatment, or herbicide treatment. Torrington Research and Extension Center 1992 and 1993 (T92 and T93) and Powell Research and Extension Center 1992 and 1993 (P92 and P93).

| Comparison | Rate | Sugarbeet Population | | | |
|---|---|---|---|---|---|
| | | T92 | P92 | T93 | P93 |
| | | 1000 pl/A | | | |
| Placement: | | | | | |
| Incorporate | | 46.4 | 32.8 | 15.9 | 33.1 |
| Before Press Wheel | | 46.4 | 31.2 | 14.9 | 29.7 |
| After Press Wheel | | 48.2 | 31.3 | 15.5 | 29.0 |
| LSD (0.05) | | 1.2 | NS | NS | NS |
| Insecticide: | (oz/1000 ft) | | | | |
| none | —— | 47.2 | 31.3 | 17.0 | 32.5 |
| chlorpyrifos | 9 | 46.4 | 31.0 | 15.8 | 31.7 |
| carbofuran | 8 | 46.0 | 30.4 | 16.1 | 32.0 |
| fonofos | 5 | 46.3 | 28.1 | 12.8 | 26.1 |
| aldicarb | 22 | 48.8 | 34.1 | —— | —— |
| terbufos | 8 | 46.6 | 32.1 | —— | —— |
| LSD (0.05) | | NS | NS | NS | NS |
| Herbicide: | (lb ai/A)† | | | | |
| none | —— | 49.9 | 31.3 | 21.1 | 34.0 |
| cycloate | 2.5/3.0 | 48.2 | 32.9 | 12.4 | 30.6 |
| ethofumesate | 2.0/2.25 | 46.2 | 31.5 | 17.0 | 30.9 |
| cycl. + etho. | 1.5+1.5/2.0+2.0 | 46.6 | 32.5 | 11.3 | 26.8 |
| diethatyl | 3.0/3.75 | 45.1 | 30.9 | —— | —— |
| etho. + diet. | 1.5+1.5/2.0+2.0 | 45.3 | 31.4 | —— | —— |
| LSD (0.05) | | 2.2 | NS | 3.4 | 4.6 |
| Mean | | 46.9 | 31.8 | 15.4 | 30.6 |

† Herbicide rates are for Torrington/Powell.

**Table 5.** Sugarbeet injury in response to herbicide treatment, and insecticide placement x herbicide treatment interations. Torrington Research and Extension Center 1992 and 1993 (T92 and T93) and Powell Research and Extension Center 1992 and 1993 (P92 and P93).

| Comparison | Rate | Sugarbeet Injury | | | |
|---|---|---|---|---|---|
| | | P92 | P92 | T93 | P93 |
| | lb ai/A[†] | | % | | |
| Herbicide: | | | | | |
| none | —— | 0.1 | 0.8 | 0.0 | 1.5 |
| cycloate | 2.5/3.0 | 6.9 | 0.5 | 2.2 | 1.6 |
| ethofumesate | 2.0/2.25 | 10.4 | 1.1 | 4.1 | 4.8 |
| cycl. + etho. | 1.5+1.5/2.0+2.0 | 15.7 | 0.4 | 8.2 | 5.1 |
| diethatyl | 3.0/3.75 | 1.7 | 0.7 | —— | —— |
| etho. + diet. | 1.5+1.5/2.0+2.0 | 8.8 | 1.1 | —— | —— |
| LSD (0.05) | | 2.8 | NS | 1.5 | 1.6 |
| Placement x Herbicide: | | | | | |
| Incorp. x none | | 0.0 | 1.0 | 0.0 | 0.9 |
| Incorp. x cycl. | | 6.0 | 1.5 | 1.3 | 1.6 |
| Incorp. x etho. | | 9.4 | 0.0 | 2.8 | 4.1 |
| Incorp. x cycl. + etho. | | 17.9 | 0.0 | 7.2 | 5.3 |
| Incorp. x | | 1.0 | 0.2 | —— | —— |
| Incorp. x etho. + diet. | | 10.0 | 0.2 | —— | —— |
| Before PW x none | | 0.0 | 0.8 | 0.0 | 2.2 |
| Before PW x cycl. | | 10.6 | 0.4 | 2.8 | 3.1 |
| Before PW x etho. | | 9.0 | 1.3 | 4.4 | 5.0 |
| Before PW x cycl. + etho. | | 18.3 | 0.4 | 8.1 | 4.4 |
| Before PW x diet. | | 1.7 | 1.0 | —— | —— |
| Before PW x etho. + diet. | | 12.9 | 0.6 | —— | —— |
| After PW x none | | 0.2 | 1.5 | 0.0 | 1.3 |
| After PW x cycl. | | 4.2 | 0.6 | 2.5 | 0.0 |
| After PW x etho. | | 12.9 | 0.2 | 5.0 | 5.3 |
| After PW x cycl. + etho. | | 10.8 | 0.8 | 9.4 | 5.6 |
| After PW x diet. | | 2.3 | 2.1 | —— | —— |
| After PW x etho. + diet. | | 3.3 | 1.3 | —— | —— |
| LSD (0.05) | | 4.1 | 1.1 | NS | NS |
| Mean | | 7.3 | 0.8 | 3.6 | 3.2 |

[†] Herbicide rates are for Torrington/Powell.

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