Response of Sugarbeet Varieties and Populations to Postemergence Herbicides

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ABSTRACT

Injury from herbicides may reduce sugarbeet yield or sugar content. Previous research has shown a differential response of sugarbeet varieties to herbicides. We evaluated the growth response of fourteen sugarbeet varieties, and four USDA sugarbeet entries (three USDA experimental hybrids and their pollinator) to postemergence applications of the micro-rate of desmedipham plus phenmedipham (1:1 ratio) at 0.09 kg ai/ha plus triflusulfuron at 0.004 kg ai/ha plus clopyralid at 0.023 kg ae/ha plus methylated seed oil at 1.5% v/v. Sugarbeets were sprayed three times at weekly intervals beginning at the cotyledon growth stage. Sugarbeet varieties differed in their response to micro-rate herbicide applications. Leaf area, fresh weight and dry weight of Hilleshog E-17 and ACH 555, two diploid varieties, were not reduced by micro-rate applications, while the leaf area of Beta 5400 and Beta 5736, two triploid varieties, was reduced by 24 and 35%, respectively, compared to their respective untreated controls. In a second experiment, the leaf area and fresh and dry weight of Spartan and Hilleshog E-17 were not reduced by postemergence micro-rate applications in the growth chamber or field, compared to their respective controls. Hilleshog E-38, ACH 185, and Beta 5736 had significant reductions in leaf area and dry weight in the growth chamber and field, while RH-5 had significant reductions in the growth chamber only, and tolerance was not correlated with ploidy level. Among the USDA materials, reductions in growth measures were evident in all entries; however, reductions in the experimental hybrid with SP85576 cms were markedly less for all traits except growth chamber dry weight (27% reduction in fresh weight, 20% reduction in leaf area and 16% reduction in

field dry weight, compared to reductions of 43%, 29% and 47% in the same measures of the pollinator, respectively) suggesting a genetic component to herbicide tolerance.

Additional key words: desmedipham; phenmedipham; ethofumesate; triflusulfuron; clopyralid; *Beta vulgaris* L.; micro-rate.

Sugarbeet (*Beta vulgaris* L.) growers face many production decisions with one of the most critical being variety selection. Sugarbeet varieties are chosen based on yield potential, cost, disease resistance, herbicide tolerance, and emergence potential. Without a uniform plant population throughout the field or region, growers will have difficulty maximizing sucrose yields (Smith *et al.,* 2001). A uniform sugarbeet population not only minimizes variability in yield and sugar content of individual sugarbeet plants, but also limits space in the field where weeds may emerge during the growing season.

Several researchers have studied sugarbeet variety susceptibility to herbicides (Dexter and Luecke, 1997; Wilson, 1999; Wilson *et al.*, 2002; and Smith and Schweizer, 1983). Sugarbeet dry weight 45 d after planting was reduced by 39 to 55% from herbicides and there was significant herbicide by variety interactions (Smith and Schweizer, 1983); however, by harvest root yield reductions averaged 5% and herbicide by variety interactions were no longer significant. Dexter and Kern (1978) reported that sugarbeet varieties responded differently to EPTC, and there was a significant herbicide by variety by year interaction. In two of three years, varieties responded differently to EPTC, but in one year there was no injury to any of the varieties from EPTC.

As new varieties are released, it is important to determine if these varieties are more or less susceptible to standard herbicide treatments. Herbicide programs in sugarbeet have changed significantly in the last ten years. In the late 1970s and early 1980s most sugarbeet weed control programs consisted of a sequential application of preplant followed by postemergence herbicides. Today, many sugarbeet growers have discontinued the use of preemergence herbicides and rely on a total postemergence program (Wilson, 1999). A common postemergence program in Michigan and other sugarbeet production regions is referred to as the micro-rate (desmedipham plus phenmedipham at 0.09 kg/ha plus triflusulfuron at 0.004 kg/ha plus clopyralid at 0.023 kg/ha plus MSO at 1.5% v/v). Sugarbeet varieties may vary in response to micro-rate herbicide applications and injury can lead to a reduction in the sugarbeet population or sucrose yield. Therefore, the objective of this experiment was to determine sugarbeet variety and population response to postemergence micro-rate herbicides. We screened twelve commercial sugarbeet varieties approved by sugar processors in Michigan, two older commercial varieties, and four USDA entries (three experimental hybrids and their pollinator). Of the fourteen sugarbeet varieties, nine were diploids and five were triploids.

MATERIALS AND METHODS

Growth Chamber Research

Commercial sugarbeet varieties and USDA entries were grown in growth chambers with a photoperiod of 16:8 h (light:dark) and thermoperiod of 24:14 C (day:night). Eight to ten sugarbeet seeds of each variety were seeded in plastic pots (10-cm square by 15-cm depth) containing a mixture of sphagnum peat and perlite, and were thinned to four plants per pot three days after emergence. Pots were watered daily as needed and fertilized once each week with (20-20-20 N-P-K) at 40 kg/ha. The postemergence micro-rate herbicide treatment was desmedipham plus phenmedipham at 0.09 kg ai/ha plus triflusulfuron at 0.004 kg ai/ha plus clopyralid at 0.023 kg ae/ha plus MSO at 1.5% v/v. Herbicides were applied three times at weekly intervals with a single tip track-sprayer equipped with an 8003E[1] spray tip calibrated to deliver 187 L ha^{-1}. Fresh and dry weights and leaf area were recorded one wk after the last treatment. In the first experiment, four varieties were compared; in the second experiment, fourteen varieties were compared. The four USDA entries were planted in the second experiment only and included WC 93404 (SP85576 cms x 92HS25), WC93406 (SP85657cms x 92HS25), WC 93407 (FC607 cms x 92HS25), and WC 93409 (92HS25, an unreleased pollinator derived from early generation smooth-root, high sucrose breeding lines developed by J. Clair Theurer). These represented a genetic population of CMS lines crossed with the same pollinator (e.g. topcross populations).

Field Research

Fourteen sugarbeet varieties and the four USDA entries were planted on April 30, 2002. Plots were four rows wide by 7.6 m, and 3 m of the two center rows in each plot were treated with herbicide. The first micro-rate was applied when sugarbeet were at the cotyledon stage and was repeated seven and fourteen days later. The herbicides applied at the micro-rate were desmedipham plus phenmedipham at 0.09 kg/ha plus triflusulfuron at 0.004 kg/ha plus clopyralid at 0.023 kg/ha plus MSO at 1.5% v/v. Herbicide treatments were applied with a back-pack compressed air sprayer equipped with an 8003E spray tip calibrated to deliver 187 L ha^{-1}. Three plants from each of the center two rows of the treated area, and three plants from each of the center two rows of the untreated area were harvested. Leaf

[1] Teejet even fan tips. Spraying Systems Co., North Ave. and Schmale Road, Wheaton, IL 60188.

area and fresh weights were recorded one week after the third micro-rate treatment, and dry weights were recorded one week later.

Statistical Analysis

The experimental design for the growth chamber research was a CRD with four replicates and repeated. Data were combined over runs and subjected to ANOVA and means were separated using Tukey's test for honestly significant differences ($HSD_{0.05}$) from the ANOVA at ($P \leq 0.05$). The experimental design for the field research was a split-plot with three replicates. Whole-plots were varieties and the sub-plots were herbicide treatment. Herbicide treatments consisted of either treated or untreated sugarbeet. Data were subjected to ANOVA and means were separated using Tukey's test for honestly significant differences ($HSD_{0.05}$) from the ANOVA at ($P \leq 0.05$).

RESULTS AND DISCUSSION

Growth Chamber Research

In the first experiment, herbicide treatments reduced fresh weight, dry weight, and leaf area of Beta 5400 and Beta 5736 compared to the untreated controls; however, there was no significant reduction in these characters for the varieties ACH 555 and HM E-17 (Table 1). The Beta varieties are triploids and the other two varieties diploids. Therefore, we wished to determine if diploid varieties were more tolerant to poste-

Table 1. Fresh weight, dry weight, and leaf area of four commercial sugarbeet varieties following three micro-rate herbicide applications in the growth chamber†.

Variety	Ploidy level	Treatment	Fresh weight	Dry weight	Leaf area
			-------- g	--------	- cm^2 --
Beta 5400	Triploid	Untreated	148*	0.78*	80*
		Treated	117	0.51	61
Beta 5736	Triploid	Untreated	140*	0.69*	75*
		Treated	98	0.39	49
ACH 555	Diploid	Untreated	136	0.75	84
		Treated	133	0.67	72
HM E-17	Diploid	Untreated	140	0.83	80
		Treated	130	0.69	69

†*Indicates significant differences between means within varieties and columns according to Tukey's test for honestly significant differences (HSD 0.05) from an ANOVA.

mergence micro-rate herbicide applications. In the following experiment we included Beta 5736 and HM E-17 and compared these two varieties to an additional twelve commercial sugarbeet varieties. The fresh weight, dry weight, and leaf area of Beta 5736, a triploid, was again reduced by the postemergence micro-rate herbicide applications, while HM E-17 was not injured. ACH 185, another triploid, had significant reductions in dry weight and leaf area, but Spartan and Beta 5451, two other triploids, were not injured by postemergence micro-rate applications. Furthermore, HM E-38, HM RH-5, ACH 913, and ACH 1353, all diploid varieties, had significant reductions in two or more of the measured variables (Table 2). Therefore, triploid varieties did not appear to be more sensitive than diploid varieties to postemergence micro-rate herbicide applications, but rather response to herbicides was variety specific.

The USDA entries varied in sensitivity to the micro-rate applications (Table 3). Leaf area of the USDA hybrid WC 93404 (SP85576 cms x 92 HS25) was reduced by only 20%, compared to a 27-29% reduction with the other USDA entries, and fresh weight of WC 93404 was reduced by only 27% compared to a 41-44% reduction with the other USDA entries, suggesting a genetic component to herbicide tolerance.

Field Research

In the field there were no significant differences in leaf area or fresh weight between varieties (data not presented). Micro-rate herbicide treatments reduced the dry weight of two triploids, Beta 5736 and ACH 185, supporting growth chamber results. Dry weight was also reduced for two other triploids, Beta 5451 and Beta 5172 (Table 2). Sugarbeet dry weight was reduced for four diploids, HM E-38, HM E-33, ACH 963, and USH 20, following postemergence micro-rate applications (Table 2). Herbicide treatments only reduced dry weight of one USDA hybrid WC 93404 by 16%, compared to a 47-48% reduction in dry weight of WC 93407 (FC607 cms x 92 HS25) and WC93409 (92 HS25), consistent with growth chamber results (Table 3). Field dry weight of WC 93406 (SP85657 cms x 92 HS25) was only reduced by 12% and no substantial growth chamber differences were observed between this and other USDA lines, unlike WC 93404.

In conclusion, sugarbeet response to postemergence micro-rate herbicide applications could not be predicted from ploidy level (Table 2). Sugarbeet varieties varied in response to micro-rate applications, and these differences may be genotypic or phenotypic. From the USDA hybrids, WC93404 (SP85576 cms x 92HS25) was more tolerant to the postemergence micro-rate applications than the other crosses and the pollinator, suggesting a genetic contribution to tolerance from the seed parent SP85576 cms. A major limitation of early season sugarbeet variety

Table 2. Fresh weight, dry weight, and leaf area of fourteen commercial sugarbeet varieties following three micro-rate herbicide treatments in the growth chamber and in the field[†].

Variety	Ploidy level	Treatment	Growth chamber: Fresh weight	Growth chamber: Dry weight	Growth chamber: Leaf area	Field: Dry weight
			-----------g-----------		---cm^2---	----g----
Spartan	Triploid	Untreated	19.5	1.6	401	10.0
		Treated	16.0	1.1	350	5.6
Prompt	Diploid	Untreated	19.5	1.8	386*	7.2
		Treated	15.3	1.1	326	4.9
HM E-17	Diploid	Untreated	18.8	1.6	389	6.7
		Treated	16.3	1.3	378	3.8
HM E-33	Diploid	Untreated	18.8	1.7	382*	7.3*
		Treated	15.0	0.9	322	4.2
HM E-38	Diploid	Untreated	22.3*	1.8*	399*	6.3*
		Treated	13.3	0.8	292	4.2
RH-5	Diploid	Untreated	20.0*	1.7*	348*	6.4
		Treated	10.9	0.7	253	5.1
ACH 963	Diploid	Untreated	19.5	1.5	382	7.5*
		Treated	16.9	1.0	320	5.1
ACH 913	Diploid	Untreated	20.4	1.6*	377*	7.6
		Treated	14.0	0.9	297	6.8
ACH 1353	Diploid	Untreated	19.0*	1.6	381*	6.4
		Treated	14.1	0.9	314	6.3
Beta 5451	Triploid	Untreated	19.3	1.5	399	9.5*
		Treated	17.3	1.1	367	5.4
Beta 5172	Triploid	Untreated	19.9	1.6	377*	7.1*
		Treated	13.3	0.8	311	4.8
Beta 5736	Triploid	Untreated	19.7*	1.4*	347*	8.3*
		Treated	12.1	0.8	263	5.9
USH 20	Diploid	Untreated	17.1	1.0	365	9.3*
		Treated	15.0	1.0*	331	5.9
ACH 185	Triploid	Untreated	22.4	1.8	432*	7.9*
		Treated	16.2	1.0	358	5.5

[†]*Indicates significant differences between means within varieties and columns according to Tukey's test for honestly significant differences (HSD 0.05) from an ANOVA.

Table 3. Fresh weight, dry weight, and leaf area of four USDA sugarbeet entries following three micro-rate herbicide applications in the growth chamber and in the field†.

Variety‡	Ploidy level	Treatment	Growth chamber			Field
			Fresh weight	Dry weight	Leaf area	Dry weight
			-------------- g	--------------	---- cm2 ----	------ g ------
WC93404	Diploid	Untreated	17.5	1.7*	362	7.7
		Treated	12.7	0.9	290	6.5
WC93406	Diploid	Untreated	18.7*	1.6*	348*	5.8
		Treated	11.0	0.8	255	5.1
WC93407	Diploid	Untreated	20.7*	1.7*	384*	8.6*
		Treated	11.5	0.8	274	4.5
WC93409-pollinator	Diploid	Untreated	17.6	1.4*	314*	7.9*
		Treated	10.0	0.7	225	4.2

†*Indicates significant differences between means within varieties and columns according to Tukey's test for honestly significant differences (HSD 0.05) from an ANOVA.

‡ WC 93404 (SP85576 cms x 92HS25), WC93406 (SP85657 cms x 92HS25), WC 93407 (FC607 cms x 92HS25), and WC 93409 (92HS25, an unreleased pollinator derived from early generation smooth-root, high sucrose breeding lines developed by J. Clair Theurer).

comparisons is the fact that seed quality varies within varieties from seed lot to seed lot and year to year. Differences in seed coatings, insecticide, and fungicide treatments, as well as environmental and harvest conditions during the year the seed is produced may affect seedling vigor and potential response to herbicides. We used the same seed lot in all experiments to try to minimize this confounding effect; however, this may have biased our results as we didn't test a range of seed lots of each variety. An interesting observation was that Beta 5736, a triploid variety that was injured by postemergence micro-rate applications in all experiments, was one of the highest yielding varieties in Michigan Sugarbeet Advancement variety trials in 2001 and 2002 (S. Poindexter, personal communication). Dexter and Luecke (1997) also reported that the highest yielding sugarbeet variety was most affected by herbicides. Therefore, early season reductions in leaf area and biomass may not necessarily cause a reduction in sugar content or yield. Increasing sugarbeet tolerance to postemergence herbicides would increase the competitiveness of sugarbeet with weeds.

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