Timing of Postemergence Micro-rate Applications based on Growing Degree Days in Sugarbeet

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ABSTRACT

Postemergence (POST) herbicides must be applied in sugarbeet when weeds are less than 2.5 cm tall, or poor weed control will result. Multiple POST applications are usually required because of continued weed emergence. Frequent POST applications may injure sugarbeet and increase herbicide/application costs; however, too few applications may result in poor weed control and reduced sugarbeet yield and quality. This research determined if growing degree days (GDD) could be used to time postemergence herbicide applications. Common lambsquarters (*Chenopodium album* L.) and redroot pigweed (*Amaranthus retroflexus* L.) were controlled in the growth chamber by three micro-rate herbicide treatments applied on seven day intervals, every 97 or 125 GDD (base temperature of 1.1° C). Two micro-rate applications also provided control of common lambsquarters and redroot pigweed when the first application was at 194 GDD (97 + 97 GDD), followed by the second application at 97 GDD (Table 1). Neither weed species was controlled by three micro-rate applications at 152 GDD, or when the first treatment was delayed until 250 GDD and only two micro-rates were applied. In the field, sugarbeets were planted April 5, April 19, and May 2 in 2001 and April 7, April 17, and May 1 in 2002. Micro-rate treatments were applied (a) every 7 d, (b) as needed, (c) every leaf pair (2001 only), (d) every 97 GDD, (e) every 125 GDD (2002 only) and (f) every 152 GDD. All treatments controlled 92% or more of the common lambsquarters in both 2001 and 2002. In 2001, *Amaranthus* spp. control was 91% with the 152 GDD treatment compared to 97%

with the 7-day treatment, and in 2002 control ranged from 80% with the 152 GDD treatment to 86% with the 7-day treatment. Although *Amaranthus* spp. control was somewhat less when the micro-rate was applied on a 152 GDD schedule, recoverable sucrose in 2001 was 7,748 kg/ha with the 152 GDD treatment compared to 6,691 kg/ha with the 7-day treatment. In 2002, recoverable sucrose was 4,935 kg/ha with the 152 GDD treatment compared to 4,261 kg/ha with the 7-day treatment. When the micro-rate was applied every 152 GDD, the total number of applications was reduced by two in 2001 and three in 2002 compared to the 7-day or labeled treatment for the early and mid-April planting dates. For the early May planting dates, the total micro-rate applications were reduced by two in both 2001 and 2002 in the 152 GDD compared to the 7-day treatment.

Additional key words: common lambsquarters, *Chenopodium album* L.; redroot pigweed, *Amaranthus retroflexus* L.; pigweed species, *Amaranthus retroflexus* and *Amaranthus powellii* S. Wats.; sugarbeet, *Beta vulgaris* L. Hilleshog E-17 and Beta 5400, herbicides, weed control.

Abbreviations: GDD, growing degree days; POST, postemergence.

Weed control in corn (*Zea mays* L.), soybean (*Glycine max* (L.) Merr.), and cotton (*Gossypium hirsutum* L.) in the United States has changed from conventional herbicides to the use of transgenic crops primarily resistant to glyphosate. Fifty four percent and 75% of the soybean crop was planted to glyphosate-resistant varieties in 2000 and 2002, respectively (Anonymous 2000; 2002). The widespread acceptance of herbicide resistant technology has shifted the focus of research from the length of time applications can be delayed and still achieve weed control to the length of time applications can be delayed to prevent yield loss (Dalley *et al.*, 2004; Rothe and Dexter, 2000; Kemp, 2000). In contrast to the very effective weed control from glyphosate in transgenic crops, POST sugarbeet herbicides seldom control weeds larger than two-true leaves so application timing is still critical to weed control. The micro-rate (a combination of desmedipham plus phenmedipham at 0.045/0.045 kg ai/ha or desmedipham plus phenmedipham plus ethofumesate at 0.03/0.03/0.03 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) is usually applied POST three to five times to young actively growing weeds at the cotyledon stage. More than one herbicide application is usually needed because weeds continue to emerge and the weed control from one application is not sufficient. Weeds not controlled by micro-rate treatments may be controlled with higher herbicide rates (standard-splits), or by hand-labor. However, standard-splits are usually applied in a band and the area between the rows cultivated to reduce herbicide costs. Hand-labor has become more expensive due to government regulations and a decrease in the available work force. Schweizer and Dexter (1987) reported that hand-labor costs doubled from $41/ha in 1970 to $82/ha in 1986. A second weeding cost $26/ha in 1970 versus $54/ha in 1986. Both standard-splits and hand-labor are costly, so many growers try to avoid these practices by applying micro-rates. Furthermore, the reduced herbicide rates allow growers to broadcast the micro-rate application, thereby reducing cultivation costs, as well as being able to apply herbicides throughout the day with less risk of sugarbeet injury. Scouting fields for weeds less than 2 cm in size is difficult and time consuming, so growers base POST herbicide applications on calendar days to minimize scouting. The ability to predict the proper timing of postemergence herbicides to optimize weed control and minimize sugarbeet injury and herbicide cost would benefit sugarbeet growers.

The use of growing degree days (GDD) to predict plant development has been used successfully for various crops (Vinocur and Ritchie, 2001; Juskiw *et al.*, 2001) and weeds (Nord *et al.*, 1999; Ball *et al.*, 1995). These GDD systems are based on air temperature. Researchers have tried to predict weed seed germination and emergence based on soil temperature and soil moisture (Roman *et al.*, 2000; Oryokot *et al.*, 1997; Harvey and Forcella, 1993; Forcella, 1993). In controlled environments, the temperature and rate of emergence of many weeds has been successfully determined. However, these models usually predict the time of 50% germination or weed emergence (Oryokot *et al.*, 1997; Harvey and Forcella, 1993; Alm *et al.*, 1993). When weeds have reached 50% emergence in the field, it is probably too late for micro-rates because a significant portion of the weeds exceed the size controlled by the micro-rate. Roman *et al.* (2000) stated that GDD based on soil temperature was a better predictor of common lambsquarters (*Chenopodium album* L.) emergence than air temperatures at one of two locations in one of two years under no-till conditions. Most of the U.S. sugarbeet crop is planted into fields that have either been chisel plowed or moldboard plowed the previous fall. Although significant research has been conducted using GDD to time insecticide applications in many crops, GDD have not been used as a schedule for multiple POST herbicide applications in crops such as sugarbeet.

The current desmedipham/phenmedipham label states that the first micro-rate treatment should be applied when weeds are at the cotyledon stage; with follow up treatments applied every 5 to 7 d, as required. This 5 to 7 d interval may be too short or too long to achieve the optimum balance between effective weed control and minimal sugarbeet injury, depending on environmental conditions between treatments. Weeds emerge and grow more rapidly under warm moist conditions than cool dry conditions. Improper timing of the micro-rate application may result in poor weed control or undue cost. A model based on soil temperature and moisture that would provide consistent results would be ideal, but may not be possible because of the influence of tillage practices, soil texture, soil type, moisture, and burial depth on weed emergence. Furthermore, soil temperature data are often not as accessible as air temperature. Growers use GDD based on air temperature for other pest management decisions; therefore, adopting GDD for timing POST herbicide applications would be feasible.

The objectives of this research were to determine if weeds could be controlled in sugarbeets by sequential POST herbicide applications based on GDD, and to compare sugarbeet injury and weed control following POST applications based on GDD to applications based upon set time intervals (calendar days).

MATERIALS AND METHODS

Growth Chamber Experiment

Common lambsquarters and redroot pigweed were planted in plastic pots (10-cm^2 by 15-cm depth) filled with a mixture of sphagnum peat and perlite. Pots were placed in a growth chamber at 27:11 C (day: night 16 h photoperiod) for 5 d and then transferred to growth chambers at 23:7, 27:11, and 31:15 C 2 d prior to the first micro-rate treatment. The 23:7 C chamber provided 97 GDD every 7 d, the 27:11 C chamber provided 125 GDD every 7 d, and the 31:15 C chamber provided 152 GDD every 7 d. GDD were calculated using the average daily temperature (in centigrade) and the base temperature of 1.1^0 C (max + min/2 - 1.1° C = GDD in C for 1 day).

All chambers had a photoperiod of 16:8 h (light:dark). Pots were watered daily as needed and fertilized once each week with (20:20:20 N-P-K). Treatments within each growth chamber included (a) no herbicides, (b) micro-rate herbicide treatments applied two times starting two wks after planting, and (c) micro-rate herbicide treatments applied three times starting one wk after planting. The micro-rate herbicide treatment was desmedipham plus phenmedipham at 0.045/0.045 kg/ha plus triflusulfuron at 0.004 kg/ha plus clopyralid at 0.023 kg/ha plus MSO at 1.5% v/v. Herbicides were applied with a single nozzle track-sprayer equipped with an 8003E[1] spray nozzle calibrated to deliver 187 L ha^{-1}. Visual observations were recorded one wk after the last treatment.

The experimental design was a split plot RCB with four replicates and was repeated. Temperature was the whole-plot factor, assigned at random to the three growth chambers within each experimental run. Herbicide treatment was the split-plot factor and each herbicide treatment was assigned at random to four pots within each chamber. Data were subjected to ANOVA using the PROC MIXED procedure in SAS and means were separated using Fishers Protected LSD at ($P \leq 0.05$).

Field Experiments

Field experiments were conducted in 2001 and 2002 near East Lansing, MI. The experiments were located on a Colwood-Brookston loam (fine-loamy, mixed, mesic Typic Haplaquolls, and fine-loamy, mixed, mesic Typic Argiaqoulls), with 53% sand, 27% silt, and 21% clay, a soil pH of 6.9, and 2.4% organic matter. Fields were fall plowed followed by field cultivation in the spring. Prior to planting sugarbeet, plots were fertilized with granular fertilizer (46-0-0) at 125 kg/ha using a broadcast applicator and incorporated with a field cultivator. In addition, granular fertilizer (19-19-19) at 110 kg/ha was applied in-furrow at planting. Hilleshog E-17 and Beta 5400, two of the top five varieties in terms of acreage in Michigan, were seeded 2.5 cm deep at 118,000 seeds/ha in 76-cm rows with a John Deere 7200 Max-Emerge® 2[2] planter. Growers had commented on differences in sugarbeet variety response to postemergence herbicides in previous years (personal communication). Seeding dates in 2001 were April 5, April 19, and May 2; in 2002 the seeding dates were April 7, April 17, and May 1. Micro-rate treatments of desmedipham plus phenmedipham at 0.045/0.045 kg/ha plus triflusulfuron at 0.004 kg/ha plus clopyralid at 0.023 kg/ha plus MSO at 1.5% v/v were applied (a) every 7 d, (b) as needed, (c) every leaf pair (2001 only), (d) every 97 GDD, (e) every 125 GDD (2002 only), and (f) every 152 GDD. The 'as needed' treatment was scouted every 3 d and sprayed when weeds were 1 cm tall. The leaf pair treatment was deleted in 2002 because of the variability in "leaf pair" growth stage in a sugarbeet population and the fact that the 2001 field research and growth chamber research indicated that 125 GDD would be better than leaf pair for timing POST herbicides. GDD were calculated using a base of 1.1° C. Herbicide treatments were applied in water at 187 L ha^{-1} and 207 kPa, through XR 8003[3] spray nozzles using

[1] Teejet even fan tips. Spraying Systems Co., North Ave. and Schmale Road, Wheaton, IL 60188.
[2] Deere and Co., 501 River Drive, Moline, IL 61265-1100.

a tractor-mounted compressed air sprayer. The first micro-rate application in all treatments at each planting date, each year, was based on when weeds had emerged and were 1 cm in height (cotyledon stage) and then repeated according to treatment until the time of sugarbeet canopy closure. In 2002, clethodim at 0.1 kg/ha was applied postemergence over the entire plot area to control 5-cm giant foxtail.

Sugarbeet injury and weed control were estimated visually 14 DAT using the rating scale of 0 (no injury) to 100 (completely killed). Sugarbeet was flailed and topped with a two-row machine, and harvested October 30, 2001 and October 21, 2002 with a mechanical two-row lifter. A sample of roots from each plot was analyzed for recoverable sucrose by Michigan Sugar Company, Caro, MI.

The experimental design was a factorial in a split-split-plot arrangement with four replicates. The whole-plot was planting date, subplot was sugarbeet variety, and sub-sub-plot was herbicide treatment. Data were subjected to ANOVA using the PROC MIXED procedure in SAS and means were separated using Fishers Protected LSD at ($P \leq 0.05$).

RESULTS AND DISCUSSION

Growth Chamber Experiment

Common lambsquarters and redroot pigweed control was 90% or more when the micro-rate was applied three times, every 97 or 125 GDD (Table 1). However, when the micro-rate was applied three times, every 152 GDD, common lambsquarters and redroot pigweed control decreased to 84% and 63% respectively. Weeds were greater than 1.5 cm tall at the time of the first application, and these weeds were not controlled with repeated micro-rate applications at 152 GDD. Interestingly, two micro-rate applications also provided control of common lambsquarters and redroot pigweed when the first application was at 194 GDD (97 + 97 GDD), followed by the second application at 97 GDD (Table 1). The timeliness of the second micro-rate application in obtaining excellent weed control is apparent. When the first micro-rate application was delayed until 250 GDD, followed by a second micro-rate application at 125 GDD, control of common lambsquarters and redroot pigweed decreased to 87% and 77%, respectively, indicating that 250 GDD is too long a time interval prior to the first micro-rate treatment, if the next micro-rate treatment is 125 GDD later. Larger weeds in sugarbeet (greater than 1.5 cm) are difficult to control with micro-rate herbicides. If the first micro-rate treatment is delayed because of field or weather conditions that prohibit herbicide

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

Table 1. Common lambsquarters and redroot pigweed control 28 days after planting with two or three POST herbicide treatments applied every 97, 125, and 152 growing degree days (C) in growth chambers.

Temperature regimes[†]	GDD	Herbicide applications[‡]	Common lambsquarters	Redroot pigweed
day:night (C)	(C)	DAP[§]	% control[††]	
23:7	97	14 and 21	100a	100a
23:7	97	7, 14, and 21	100a	100a
27:11	125	14 and 21	87c	77c
27:11	125	7, 14, and 21	95b	90b
31:15	152	14 and 21	52d	34e
31:15	152	7, 14, and 21	84c	63d

[†]Common lambsquarters and redroot pigweed were grown in growth chambers set at 23:7 C (97 GDD every 7 d), 27:11 C (125 GDD every 7 d), and 31:15 C (152 GDD every 7 d).

[‡]Herbicide treatments were applied 14 and 21 d after planting or 7, 14, and 21 d after planting. In the 14 and 21 treatment, the first application at 14 days was applied at 2 (GDD), i.e. 2(97)=194 GDD at 14 DAP, followed by an application at 97 GDD, 21 DAP. Herbicides applied were desmedipham plus phenmedipham at 0.045/0.045 kg/ha plus triflusulfuron at 0.004 kg/ha plus clopyralid at 0.023 kg/ha and methylated seed oil at 1.5% v/v.

[§]Abbreviations: DAP, days after planting.

[††]Means within a column followed by the same letter are not different, according to Fisher's protected LSD at $P = 0.05$.

application, shortening the GDD accumulation to 97 GDD may improve control of these weed species.

Field Experiment

Sugarbeets grew slowly, regardless of planting date, as the time to two true leaves ranged from 24 to 33 days after planting (Table 2). Rainfall in May 2001 was 13 cm above normal and May temperatures were 1.7° C above normal, resulting in more rapid sugarbeet growth. However, weeds never exceeded 1.3 cm in height in any treatment, and were usually 0.3 to 0.6 cm tall and at the cotyledon stage.

Planting date by variety and treatment by variety by planting date interactions were not significant; therefore, the data were combined over varieties and planting dates for the analyses of the field study.

Number and Timing of Micro-rate Applications

When the micro-rate was applied every 152 GDD, the total number of micro-rate applications was reduced by two in 2001 and three in 2002 compared to the 7 d (labeled) treatment for the early and mid-April planting dates (Tables 2). The time between the first and second micro-rate application, when using 152 GDD, was 12 and 20 days for the early April planting date in 2001 and 2002, respectively, and 12 and 18 days for the mid-April planting date in 2001 and 2002, respectively (Tables 2). Cooler temperatures in April compared to May and June slow weed emergence and growth. For the early May planting dates, the number of micro-rate applications was reduced by two in both 2001 and 2002 in the 152 GDD compared to the 7 d treatment (Tables 2). The time between the first and second micro-rate application was 10 d in 2001 and 17 d in 2002 with the 152 GDD treatment.

Often in the 7 d treatment there would be no weeds or weeds would be less than 0.3 cm at the time of application. The number of micro-rate applications when timed at a 7-d calendar interval was 7 or greater, regardless of planting date. In Michigan, growers seldom apply more than five micro-rates. Therefore, growers are deviating from a calendar schedule or they stop spraying prior to canopy closure and rely on cultivation. The mean number of days between herbicide applications was 4.5 d greater for the 152 GDD timing for all planting dates in 2001 and 2002, and was 4 d greater for the 125 GDD timing in the early and late planting dates of 2002 compared to the 7 d timing. This lengthening of the time interval between applications reduces herbicide costs and is advantageous if weeds are controlled.

Sugarbeet Response

Table 2a. Herbicide application dates for three planting dates in 2001 and 2002. Weeds at the time of application were 0.3 to 0.6 cm tall and at the cotyledon stage.

Application Timing									
April 5, 2001 planting date					**April 7, 2002 planting date**				
7-day†	'As needed'	Lf-pair	97 GDD	152 GDD	7-day†	'As needed'	97 GDD	125 GDD	152 GDD
4/26	4/26	4/26	4/26	4/26	4/16	4/16	4/16	4/16	4/16
5/02	5/02	5/04	5/04	5/08	4/23	5/01	5/01	5/01	5/06
5/13	5/20	5/13	5/13	5/20	5/01	5/14	5/14	5/14	5/21
5/20	5/30	5/20	5/20	6/04	5/06	5/28	5/28	6/01	6/01
5/26		5/30	5/30	6/14	5/14	6/07	6/07	6/07	6/07
6/04		6/11	6/08		5/20	6/14	6/19	6/19	6/19
6/11			6/14		5/28	6/19	6/22	6/25	
					6/07				
					6/14				
Total									
7	4	6	7	5	9	7	7	7	6

† Sugarbeets were at the two leaf stage on May 8, 2001 and May 6, 2002, 33 and 29 days after planting, respectively. Sugarbeets were at the four leaf stage on May 13, 2001 and May 14, 2002.

Table 2b. Herbicide application dates for three planting dates in 2001 and 2002. Weeds at the time of application were 0.3 to 0.6 cm tall and at the cotyledon stage.

Application Timing									
April 19, 2001 planting date					**April 17, 2002 planting date**				
7-day†	'As needed'	Lf-pair	97 GDD	152 GDD	7-day†	'As needed'	97 GDD	125 GDD	152 GDD
5/02	5/02	5/02	5/02	5/02	5/06	5/06	5/06	5/06	5/06
5/08	5/13	5/13	5/08	5/14	5/14	5/14	5/20	5/21	5/24
5/13	5/26	5/20	5/14	5/26	5/20	5/28	6/01	6/01	6/07
5/20	6/14	5/30	5/20	6/11	5/28	6/07	6/10	6/10	6/19
5/26	6/23	6/08	5/30	6/23	6/07	6/14	6/19	6/19	7/01
6/04	6/29	6/23	6/08		6/14	6/19	6/22	6/25	
6/11		6/29	6/14		6/22	6/25	6/28		
			6/23		6/28				
Total									
7	6	7	8	5	8	7	7	6	5

† Sugarbeets were at the two leaf stage on May 13, 2001 and May 18, 2002, 24 and 31 days after planting, respectively. Sugarbeets were at the four leaf stage May 20, 2001 and May 24, 2002.

Table 2c. Herbicide application dates for three planting dates in 2001 and 2002. Weeds at the time of application were 0.3 to 0.6 cm tall and at the cotyledon stage.

Application Timing									
May 2, 2001 planting date					May 1, 2002 planting date				
7-day†	'As needed'	Lf-pair	97 GDD	152 GDD	7-day†	'As needed'	97 GDD	125 GDD	152 GDD
5/14	5/14	5/14	5/14	5/14	5/14	5/14	5/14	5/14	5/14
5/20	5/26	5/20	5/20	5/24	5/20	5/28	5/28	6/01	6/01
5/26	6/8	6/4	5/30	6/10	5/28	6/14	6/10	6/10	6/14
6/4	6/23	6/11	6/8	6/23	6/07	6/19	6/19	6/19	6/22
6/11	6/29	6/23	6/14	7/02	6/14	6/25	6/25	6/28	7/01
6/23		6/29	6/23		6/22				
6/29			6/29		6/28				
Total									
7	5	6	7	5	7	5	5	5	5

† Sugarbeets were at the two leaf stage on May 26, 2001 and June 1, 2002, 24 and 31 days after planting, respectively. Sugarbeets were at the four leaf stage on June 4, 2001 and June 7, 2002.

The sugarbeet variety Beta 5400 tended to incur greater injury than Hilleshog E-17 (personal observation), but the differences were not significant and the data were combined. Sugarbeet injury was greater in the 7 d compared to the 152 GDD treatment in 2001 and greater compared to all other treatments in 2002 (Table 3). Sugarbeet plants were not as large in the 7 d treatment compared to the 152 GDD treatment, but sugarbeet populations were not reduced (data not presented). Furthermore, sucrose yield was greater in the 152 GDD and leaf pair treatments than in the 7 d and 'as needed' treatments in 2001. In 2002, sucrose yield was significantly greater in all treatments as compared to the 7 d treatment. Therefore, sugarbeet injury was less and sucrose yield greater in the 152 GDD micro-rate treatment compared to the 7 d calendar treatment in both years.

Weed Response

Common lambsquarters and *Amaranthus* spp. populations were high in both years (120 of each species per m^2); other weeds present at very low, non-uniform densities were common ragweed (*Ambrosia artemisiifolia* L.), velvetleaf (*Abutilon theophrasti* Medik), eastern black nightshade (*Solanum ptycanthum* Dunn.), and giant foxtail (*Setaria faberi* Herrm.) Common lambsquarters control was

Table 3. Sugarbeet injury 14 days after the last micro-rate herbicide application and sugar yield as affected by herbicide treatments in 2001 and 2002.

Treatment†	Sugarbeet injury‡§		Recoverable sucrose‡§††	
	2001	2002	2001	2002
	%		Kg ha^{-1}	
7 d	27a	29a	6,691b	4,261b
As needed	23ab	18b	6,612b	4,700a
Leaf pair	24ab	-	7,493a	-
97 GDD	23ab	18b	7,131ab	4,890a
125 GDD	-	20b	-	4,710a
152 GDD	18b	19b	7,748a	4,935a

† Herbicides applied were desmedipham plus phenmedipham at 0.045/0.045 kg/ha plus triflusulfuron at 0.004 kg/ha plus clopyralid at 0.023 kg/ha and methylated seed oil at 1.5% v/v.

‡ Means within a column followed by the same letter are not different, according to Fisher's protected LSD at $P = 0.05$.

§The leaf pair treatment was replaced with the 125 growing degree day

Table 4. Common lambsquarters and *Amaranthus* species control by herbicide treatments in 2001 and 2002.

Treatment†	Common lambsquarters‡		*Amaranthus* species‡	
	2001	2002	2001	2002
	% control‡			
7 d	97a	96ab	97a	86a
As needed	99a	96ab	86c	83a
Leaf pair	99a	-	96a	-
97 GDD	100a	96ab	99a	84a
125 GDD	-	93bc	-	83a
152 GDD	97a	92c	91b	80a

† Herbicides applied were desmedipham plus phenmedipham at 0.045/0.045 kg/ha plus triflusulfuron at 0.004 kg/ha plus clopyralid at 0.023 kg/ha and methylated seed oil at 1.5% v/v.
‡ Means within a column followed by the same letter are not different, according to Fisher's protected LSD at $P = 0.05$.

excellent with all treatments in 2001 (Table 4). In 2002, control was less in the 152 GDD treatment compared to the 7 d, 'as needed', and 97 GDD treatments (Table 4). However, control was still greater than 90%. Control of *Amaranthus* spp. was greater with the 7 d, leaf pair, and 97 GDD treatments than with the 'as needed' and 152 GDD treatments in 2001. *Amaranthus* spp. control in 2002 ranged from 86% with the 7 d treatment to 80% with the 152 GDD in 2002 and differences among treatments were not significant.

CONCLUSIONS

In the growth chamber, timing the micro-rate application by 97 or 125 GDD controlled common lambsquarters and redroot pigweed, but weed control decreased if applications were based on 152 GDD. In the field weed control, in general, was somewhat reduced as the time between micro-rate applications was extended and as total micro-rate applications decreased. However, sucrose yield from the 152 GDD treatment was similar to or greater than sucrose yield from the other micro-rate treatments in both years. The cost of one micro-rate application was approximately $50/ha, not including application cost in 2002. By applying the micro-rate using GDD, two or three micro-rate applications were eliminated while maintaining sucrose yields similar to or greater than the 7 d calendar micro-rate treatment. Sugarbeet growers could save up to $150/ha in herbicide costs by using GDD to time micro-rate applications compared to the 7 d calendar treatment regardless of planting date. This cost is magnified when factors such as sugarbeet injury, compaction, equipment depreciation, and labor costs are considered. Timing micro-rate herbicide application in sugarbeets by GDD will improve weed control and reduce time and input costs.

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