Postemergence Herbicide Timing for Maximum Weed Control in Sugarbeet†

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ABSTRACT

A three-year experiment was conducted near Scottsbluff, Nebraska to examine the effect of sugarbeet growth stage and weed height on the effectiveness of sequentially applied postemergence herbicide treatments. Sugarbeet injury averaged 9% when sequential herbicide application began when the crop was in the cotyledon growth stage. Crop injury declined if herbicide application was delayed until sugarbeet was in the 2 to 4, 4 to 6, or 6 to 8 true-leaf stage. Weed control averaged 93% for postemergence herbicides when the initial herbicide treatment was applied when the crop had 2 true-leaves and average weed height was 2 cm. Applying herbicides earlier or later than the 2 to 4 true-leaf stage resulted in reduced weed control. When desmedipham plus phenmedipham and desmedipham plus phenmedipham plus ethofumesate were applied at the 2 true-leaf growth stage, average weed control was similar between the two treatments, 92 versus 95%, respectively. As the crop and weeds grew and sugarbeet reached the 4 true-leaf growth stage, desmedipham plus phenmedipham plus ethofumesate controlled weeds better than desmedipham plus phenmedipham (85 versus 57%).

Additional Key Words: Clopyralid, crop growth stage, desmedipham, ethofumesate, phenmedipham, triflusulfuron.

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Weeds are a major problem in growing sugarbeet (*Beta vulgaris* L). Weeds that emerge soon after planting sugarbeet are more competitive than late-emerging weeds (Dawson, 1965, Weatherspoon and Schweizer, 1969). Dawson (1965) found sugarbeet growing in Washington State needed a 12-week, weed-free period after planting to ensure optimum root yields. In Nebraska, weeds that emerged with sugarbeet and grew the entire season reduced root yield 90% (Wicks and Wilson, 1983). If the crop was kept weed free until the sugarbeets reached the 2 true-leaf stage, root yields were reduced 26% by weeds emerging after this period. If the crop was kept weed free until it reached the 6 to 8 true-leaf stage, invading weeds reduced root yields 8%. Keeping the sugarbeet crop free of weeds until it reached the 8 to 10 true-leaf stage, or 10 weeks after planting, ensured maximum root yields.

Sequential herbicide application at planting and after crop emergence have proven effective in providing early season weed control (Schweizer, 1980; Winter and Wiese, 1982; Wicks and Wilson, 1983; Miller and Fornstrom, 1989). Other popular weed control programs have omitted the use of herbicides at planting and relied on postemergence weed management (Wilson, 1992; Wilson, 1994). Sugarbeet response to postemergence applied herbicides is influenced by crop growth stage (Eshel, Schweizer and Zimdahl, 1976). More sugarbeet foliar injury occurred when desmedipham was applied at the cotyledon growth stage compared to the 6 true-leaf stage. However, if desmedipham application was delayed until sugarbeet reached the 6 true-leaf stage, weeds were larger and desmedipham failed to provide satisfactory control.

Triflusulfuron and clopyralid have been approved for postemergence application in sugarbeet (Wilson, 1994; Eilson, 1995). When triflusulfuron was mixed with desmedipham plus phenmedipham, kochia (*Kochia scoparia* (L) Schrad.) control improved while clopyralid has improved control of common sunflower (*Helianthus annuus* L.) and common cocklebur (*Xanthium strumarium* L.).

The objective of this experiment was to determine the effect of weed size and sugarbeet growth stage on weed control and crop injury from mixtures of triflusulfuron or clopyralid with desmedipham plus phenmedipham.

MATERIALS AND METHODS

Field experiments were initiated near Scottsbluff, Nebraska in the spring of 1994, 1995 and 1996. The soil was a Tripp sandy loam (Typic Haplustoll) with pH 8 and 1% organic matter. Plots were located in a different field each year and each field was moldboard plowed and roller harrowed during the first week of April. The experimental design was a split plot with four main plots of sugarbeet growth stages and weed heights, eight subplots of weed control treatments, and four replicates. Crop growth stages and weed heights on the first application date were: 1) sugarbeet in the cotyledon stage, average weed height 1 cm; 2) sugarbeet in the 2 true-leaf stage, average weed height 2 cm; 3) sugarbeet in the 4 true-leaf stage, average weed height 4 cm; and 4) sugarbeet in the 6 true-leaf stage, average weed height 9 cm (Table 1). The eight subplots consisted of a non-treated control and seven sequential postemergence herbicide treatments listed in Table 2. The sequential post emergence herbicide treatment was obtained by applying two herbicide treatments to each plot. The first treatment was applied when the crop was in one of the four growth stages listed above and the second treatment was applied 5 to 8 days later. Individual subplots were 3.3. m by 12.2 m. Herbicides were applied broadcast in water at 187 L per hectare with a tractor mounted sprayer.

Sugarbeet was planted on the following dates: 'Seedex SX1' on April 13, 1994 and 'American Crystal 184' on May 2, 1995 and April 22, 1996. Sugarbeet was planted in rows spaced 56 cm apart at a rate of 180 seed per 3 m of row. In 1994 and 1996, sugarbeet was furrow irrigated on April 18 and April 22, respectively, to enhance sugarbeet seed germination. Beginning in July of each year, the crop was furrow irrigated as needed throughout the remainder of the growing season.

Sugarbeet injury was estimated visually 10 days after the last treatment on a scale where 0=no injury and 100=completely killed. Injury ratings were transformed to $(x + 0.5)^{½}$. However, transformation of the data did not influence data interpretation; therefore, non-transformed means are presented. Sugarbeet and weed densities were recorded in an 8.5 m^2 area in the center of each subplot 15 days after the final herbicide treatment. After weed density was recorded, remaining weeds were removed from the subplot by cultivation and

Table 1. Sugarbeet growth stage, weed height, and environmental conditions at the time of herbicide applications at Scottsbluff NE in 1994 through 1996.

Treatment date							
First application	Second application	Air temperature	Humidity	Time of day	Sugarbeet growth stage	Average weed height	Redwood pigweed height
		C	%			cm	
			1994				
May 9		11.6	46	9AM	cotyledon	1	0
	May 16	15.5	54	9 AM	2 true-leaves		
May 13		15.5	52	8 AM	2 true-leaves	2	1
	May 20	18.3	32	8 AM	4 true-leaves		
May 18		15.5	39	8 AM	4 true-leaves	4	2
	May 25	12.2	72	8 AM	6 true-leaves		
May 23		17.7	47	8 AM	6 true-leaves	11	7
	May 31	13.3	32	9 AM	8 true-leaves		
			1995				
June 1		20.5	36	10 AM	cotyledon	1	0
	June 7	20.0	41	2 PM	2 true-leaves		
June 7		20.0	41	2 PM	2 true-leaves	2	1
	June 12	29.4	22	4 PM	4 true-leaves		

Table 1. *(Continued).* Sugarbeet growth stage, weed height, and environmental conditions at the time of herbicide applications at Scottsbluff NE in 1994 through 1996.

Treatment date							
First application	Second application	Air temperature	Humidity	Time of day	Sugarbeet growth stage	Average weed height	Redwood pigweed height
		C	%			cm	
		1995 *(Continued)*					
June 12		29.4	22	4 PM	4 true-leaves	4	1
	June 19	20.0	49	8 AM	6 true-leaves		
June 15		28.3	26	7 AM	6 true-leaves	6	2
	June 21	19.4	64	8 AM	8 true-leaves		
		1996					
May 13		25.0	25	2 PM	cotyledon	1	0
	May 20	20.0	41	2 PM	2 true-leaves		
May 20		20.0	41	2 PM	2 true-leaves	2	1
	May 29	29.4	22	2 PM	4 true-leaves		
May 29		29.4	22	2 PM	4 true-leaves	6	3
	June 3	20.0	49	3 PM	6 true-leaves		
June 3		28.3	26	3 PM	6 true-leaves	12	5
	June 10	19.4	64	4 PM	8 true-leaves		

Table 2. Effect of sequential herbicide treatments averaged over years, sugarbeet growth stages and weed heights on sugarbeet injury at Scottsbluff, NE in 1994, 1995 and 1996.

		Sugarbeet			
Treatment	Rate	Visible injury	Stand	Root yield	Sucrose
	kg/ha	%	plants/ha	t/ha	%
1. Nontreated control†		0	95300	56.9	15.4
2. Desmedipham + phenmedipham‡	0.18 + 0.18	5	95200	59.8	15.4
3. Desmedipham + phenmedipham + triflusulfuron§	0.18+0.18+0.018	7	94800	56.7	15.4
4. Desmedipham + phenmedipham + clopyralid§	0.18+0.18+0.1	5	95300	57.4	14.8
5. Desmedipham + phenmedipham + triflusulfuron	0.18+0.18+0.018				
Desmedipham + phenmedipham + clopyralid	0.18+0.18+0.1	7	96700	56.7	15.2
6. Desmedipham + phenmedipham +	0.14+0.14+0.13				
Desmedipham + phenmedipham + ethofumesate	0.18+0.18+0.18	10	98200	56.8	15.5
7. Desmedipham + phenmedipham + ethofumesate	0.14+0.14+0.13				
Desmedipham + phenmedipham + clopyralid	0.18+0.18+0.10	7	95200	59.7	15.1
8. Desmedipham + phenmedipham + ethofumesate + triflusulfuron	0.14+0.14+0.13+ 0.018				
Desmedipham + phenmedipham + ethofumesate + clopyralid	0.18+0.18+0.18+ 0.10	10	95700	60.8	15.3
LSD (P = 0.05)		1	NS	NS	0.4

†The nontreated control was handweeded following early season weed counts.

‡Herbicide treatments were applied twice with 5 to 8 days between applications.

number with a mechanical two-row harvester. A 9-kg subsample from each plot was washed, weighed after drying, and analyzed for sucrose content (Anonymous, 1955).

Data on sugarbeet vigor, stand, root yield and weed density were analyzed by ANOVA followed by a comparison of main plot and subplot means using the Fisher's Protected Least Significant Difference (LSD) Test. Year by treatment interactions were not significant, so data from the 3-yr period were pooled.

RESULTS AND DISCUSSION

Sugarbeet growth stage influenced the amount of crop injury observed following sequential herbicide applications (Table 3). Sugarbeet injury was greatest when sequential herbicide application began when the crop was in the cotyledon growth stage. Crop injury declined 3%, if herbicide application was delayed until sugarbeet was in the 2 to 4 or 4 to 6 true-leaf stage. Waiting till the crop was in the 6 to 8 true-leaf stage reduced crop injury 5% compared to that observed when herbicides were applied at the cotyledon growth stage. Applying sequential postemergence herbicides at different crop growth stages did not influence sugarbeet stand or sucrose yield.

Table 3. Effect of sugarbeet growth stage and weed height on crop injury and weed control averaged over years and seven sequentially applied post-emergence herbicides at Scottsbluff, NE in 1994, 1995 and 1996.

		Sugarbeet			Weed Control		
Sugarbeet growth stage	Average weed height	Visual injury	Stand	Sucrose yield	Common lambsquarters	Redroot pigweed	Average†
	cm	%	plants/ha	kg/ha	%		
Cotylodons	1	9	95600	8870	77	55	67
2 to 4 true-leaves	2	6	96100	8600	95	91	93
4 to 6 true-leaves	4	6	94400	9140	84	59	78
6 to 8 true-leaves	10	4	97100	8870	66	74	66
LSD (P = 0.05)		1	NS	NS	16	27	10

†Average weed control includes: common lambsquarters, redroot pigweed, hairy nightshade, common cocklebur, kochia, swamp smartweed, and green foxtail.

Average weed height influenced weed control obtained from sequential herbicide applications. Weed control averaged 93% for postemergence herbicides when the initial herbicide treatment was applied when the crop had 2 true-leaves and average weed height was 2 cm (Table 3). Applying herbicides at an earlier crop growth stage and smaller weed size reduced weed control. The reduction in weed control was due to a lack of redroot pigweed (*Amaranthus retroflexus* L.) control. Redroot pigweed had not emerged when herbicides were applied at the cotyledon growth stage (Table 1). When herbicide application was delayed until the crop reached the 2 true-leaf stage, redroot pigweed had emerged and was susceptible to control from herbicides. Weed control declined rapidly as weeds became larger and sugarbeet reached the 4 to 6 true-leaf growth stage. Sugarbeet progressed from the 2 to 4 true-leaf stage to the 4 to 6 true-leaf stage in 6 to 7 days. During this period, average weed height increased from 2 to 4 cm and average weed control declined 15%. If herbicide application was further delayed and herbicide treatments were initiated when sugarbeet was in the 6 to 8 true-leaf stage and average weed height was 10 cm, weed control averaged 66%, a 27% decline from control achieved when herbicide treatments were initiated when the crop was in the 2 true-leaf stage.

In recent years, desmedipham plus phenmedipham have been recognized as standard sequential postemergence herbicides in the Nebraska sugarbeet growing area. Crop injury from a sequential application of desmedipham plus phenmedipham was 5% when averaged over the four sugarbeet growth stages (Table 2). The addition of triflusulfuron to desmedipham plus phenmedipham increased sugarbeet injury 2% over that observed when desmedipham plus phenmedipham was applied alone. Adding ethofumesate to desmedipham plus phenmedipham doubled sugarbeet injury over that observed with desmedipham plus phenmedipham. This is in agreement with previous studies that have shown a doubling of sugarbeet injury when ethofumesate was added to sequential postemergence desmedipham plus phenmedipham treatments (Wilson, 1994).

Sugarbeet stand and root yield were not influenced by sequentially applied postemergence herbicide treatments (Table 2). The lack of response of sugarbeet root yield to herbicides and application timing was probably due to the removal of weed escapes during the first

week of July with cultivation and hand weeding. Sucrose content was influenced by herbicide treatments. Compared to the nontreated control, a sequential application of desmedipham plus phenmedipham plus clopyralid reduced percent sucrose 0.6. When clopyralid was applied once, with the second sequential herbicide application, percent sucrose was not reduced. Other experiments have also shown that clopyralid plus desmedipham plus phenmedipham at 0.2 plus 0.27 plus 0.27 kg/ha increased sugarbeet injury, and in some years, reduced sugarbeet sucrose yield (Wilson, 1995).

Average weed control from a sequential postemergence desmedipham plus phenmedipham application was 64% when averaged over the four sugarbeet growth stages (Table 4). The addition of triflusulfuron or clopyralid to desmedipham plus phenmedipham increased average weed control 16 and 12%, respectively. Adding triflusulfuron to desmedipham plus phenmedipham improved kochia and swamp smartweed (*Polygonum coccineum* Muhl. ex Willd.) control over that achieved with desmedipham plus phenmedipham. When triflusulfuron was only added to the first application of desmedipham plus phenmedipham and clopyralid replaced triflusulfuron in the second application, kochia control declined, which points out the benefit of two applications of triflusulfuron. Adding clopyralid to desmedipham plus phenmedipham improved hairy nightshade (*Solanum sarrachoides* Sendtner), swamp smartweed and common cocklebur control over that achieved with desmedipham plus phenmedipham. Ethofumesate combined with desmedipham plus phenmedipham improved hairy nightshade and swamp smartweed control. Another effective sequential postemergence herbicide program was to apply desmedipham plus phenmedipham plus ethofumesate plus triflusulfuron as the first treatment followed by desmedipham plus phenmedipham plus ethofumesate plus clopyralid.

Another aspect of this study was to determine if sequential postemergence herbicide programs performed differently when applied at different stages of sugarbeet growth or weed heights. When desmedipham plus phenmedipham and desmedipham plus phenmedipham plus ethofumesate were applied at the 2 to 4 true-leaf growth stage, average weed control was similar between the two treatments, 92 versus 95% respectively (Table 5). As sugarbeet reached the 4 to 6 true-leaf growth stage, desmedipham plus phenmedipham plus ethofumesate controlled weeds better than desmedipham plus

Table 4 Effect of sequential herbicide treatments averaged over years, sugarbeet growth stages and weed heights on weed control at Scottsbluff, NE in 1994, 1995 and 1996..

	Treatment	Rate	Weed Control							
			Common cocklebur	Common lambsquarters	Hairy nightshade	Green foxtail	Kochia	Redroot pigweed	Swamp smartweed	Average
		kg/ha	%							
1.	Nontreated control		0	0	0	0	0	0	0	0
2.	Desmedipham + phenmedipham†	0.18+0.18	82	76	74	19	74	44	74	64
3.	Desmedipham + phenmedipham+ triflusulfuron†	0.18+0.18+0.018	81	83	80	42	99	76	99	80
4.	Desmedipham + phenmedipham+ clopyralid†	0.18+0.18+0.1	99	89	97	39	50	65	93	76
5.	Desmedipham + phenmedipham+ triflusulfuron	0.18+0.18+0.018								
	Desmedipham + phenmedipham+ clopyralid	0.18+0.18+0.1	99	88	83	53	88	67	80	79
6.	Desmedipham + phenmedipham+ ethofumesate	0.14+0.14+0.13								
	Desmedipham + phenmedipham+ ethofumesate	0.18+0.18+0.18	74	85	93	46	80	76	99	79
7.	Desmedipham + phenmedipham+ ethofumesate	0.14+0.14+0.13								
	Desmedipham + phenmedipham+ clopyralid	0.18+0.18+0.1	99	69	90	58	93	75	99	83
8.	Desmedipham + phenmedipham+ ethofumesate+triflusulfuron	0.14+0.14+0.13+ 0.018								
	Desmedipham + phenmedipham+ ethofumesate + clopyralid	0.18+0.18+0.18+ 0.1	93	89	86	43	99	78	99	84
	LSD (P=0.05)		16	23	11	NS	20	38	13	11

†Herbicide treatments were applied twice with 5 to 8 days between applications.

phenmedipham, 85 versus 57%, respectively. This trend continued, and when the crop had reached the 6 to 8 true-leaf stage, desmedipham plus phenmedipham controlled weeds 57% while desmedipham plus phenmedipham plus ethofumesate averaged 72% weed control.

As sugarbeet growers design postemergence herbicide weed control programs, they should consider herbicide application timing and weed species to be controlled. The optimum application period to apply the first herbicide treatment is when the crop has 2 true-leaves and weeds average 2 cm in height followed by a second application approximately a week later when the crop is in the 4 true-leaf stage. What herbicide treatment to utilize should be determined by identifying weed species. For example, if the weed population consists of common lambsquarters *(Chenopodium album* L.) and kochia, a sequential treatment of desmedipham plus phenmedipham plus triflusulfuron would provide the best weed control. If the weed population consists of common cocklebur, hairy nightshade, and swamp smartweed, a sequential treatment of desmedipham plus phenmedipham plus clopyralid would be more appropriate for the weed spectrum.

LITERATURE CITED

Anonymous. 1955. Official methods of analysis (8th ed.), Assoc. Analyt. Chem., Washington, DC. Pages 564-568.

Dawson, J.H. 1965. Competition between irrigated sugarbeets and annual weeds. Weeds 13:245-249.

Eshel, Y., E.E. Schweizer and R.L. Zimdahl. 1976. Sugarbeet tolerance of post-emergence applications of desmedipham and ethofumesate. Weed Res. 16:249-254.

Miller, S.D.and K.J. Fornstrom. 1989. Weed control and labor requirements in sugarbeets. J. Sugar Beet Res. 26(3&4): 1-9.

Schweizer, E.E. 1980. Herbicides applied sequentially for economical control of annual weeds in sugarbeets. Weed Sci. 28:152-159.

Weatherspoon, D.M. and E.E. Schweizer. 1969. Competition between kochia and sugarbeets. Weed Sci. 17:464-467.

Wicks, G.H. and R.G. Wilson. 1983. Control of weeds in sugarbeets *(Beta vulgaris)* with hand hoeing and herbicides. Weed Sci.

Table 5. Effect of sequential herbicide treatments applied at different sugarbeet growth stages and weed heights on weed control at Scottsbluff, NE in 1994, 1995 and 1996.

Sugarbeet stage of growth	Average weed height	Treatment	Average weed control†
	(cm)		(%)
Cotyledon	1	Desmedipham +‡ phenmedipham	50
		Desmedipham + phenmedipham + ethofumesate	67
2 to 4 true-leaves	2	Desmedipham + phenmedipham	92
		Desmedipham + phenmedipham + ethofumesate	95
4 to 6 true-leaves	4	Desmedipham + phenmedipham	57
		Desmedipham + phenmedipham + ethofumesate	85
6 to 8 true-leaves	10	Desmedipham + phenmedipham	57
		Desmedipham + phenmedipham + ethofumesate	72
LSD (P=0.05)			14

†Weed control was averaged over the 1994, 1995 and 1996 growing seasons.
‡Herbicide treatments were applied twice with 5 to 8 days between applications.

Winter, S.R. and A.F. Wiese. 1982. Economical control of weeds in sugarbeets *(Beta vulgaris).* Weed Sci. 30:620-623.

Wilson, R.G. 1992. Sequential herbicide application for weed control in sugarbeets. J. Sugar Beet Res. 29:1-7.

Wilson, R.G. 1994. New herbicides for postemergence application in sugarbeet *(Beta vulgaris).* Weed Technol. 8:807-811.

Wilson, R.G. 1995. Response of sugarbeet, common sunflower, and common cocklebur to clopyralid or desmedipham plus phenmedipahm. J. Sugar Beet Res. 32:89-97.