Weed Control in Sugar Beets with Triflusulfuron as Influenced by Herbicide Combination, Timing, and Rate[†]

Don W. Morishita and Robert W. Downard
University of Idaho
Twin Falls Research and Extension Center
P.O. Box 1827, Twin Falls, ID 83303-1827

ABSTRACT

Broadleaf weed control with triflusulfuron applied alone, sequentially, and in tank mixture with several herbicides registered for use in sugar beets was evaluated in field experiments. Triflusulfuron applied alone or after a soil-applied herbicide did not satisfactorily or consistently control redroot pigweed *(Amaranthus retroflexus)*, common lambsquarters *(Chenopodium album)*, hairy nightshade *(Solanum sarrachoides)*, and kochia *(Kochia scoparia)*. When triflusulfuron was tank mixed with desmedipham and phenmedipham, weed control was more consistent and equally effective with later applications when weeds were larger. Compared to using phenmedipham and desmedipham alone, triflusulfuron plus phenmedipham and desmedipham improved kochia control.

Additional Key Words: cycloate, desmedipham, diethatyl, ethofumesate, phenmedipham, *Beta vulgaris* L., common lambsquarters *(Chenopodium album* L.), hairy nightshade *(Solanum sarachoides* Sendtner), kochia *(Kochia scoparia* (L.) Schrad.), redroot pigweed *(Amaranthus retroflexus* L.), sequential herbicide applications.

[†] Idaho Agriculture Experiment Station Manuscript No. 94720.

The economic loss in sugar beets due to weeds when no herbicides are used is estimated to exceed $350 million nationwide while losses due to weeds still exceed $60 million when best management practices are used for weed control (Bridges, 1992). Kochia *(Kochia scoparia* (L.) Schrad.), nightshade species *(Solanum* spp.), redroot pigweed *(Amaranthus retroflexus* L.), and common lambsquarters, *(Chenopodium album* L.) are considered to be the most difficult weeds to control in sugar beets in Idaho (Bridges, 1992). It is well documented that weeds reduce sugar beet yields (Dawson, 1965; Schweizer, 1973, 1981, 1983; Schweizer and Bridge, 1982; Schweizer and Lauridson, 1985; Weatherspoon and Schweizer, 1969).

Weeds usually can be controlled with currently registered sugar beet herbicides as long as they are applied properly and at the correct stage of crop and weed growth (Schweizer, 1980; Wilson, 1993). However, broadleaf weeds are most susceptible to postemergence herbicides when they are very small. For example, kochia is most susceptible to phenmedipham plus desmedipham from the cotyledon stage to about 1 cm in diameter. Consequently, kochia control is difficult because it is susceptible to postemergence herbicides for such a short time period.

Sulfonylurea herbicides were developed in the mid-1970s (Beyer et al., 1988). This class of herbicides became commercially available with the introduction of chlorsulfuron in the mid-1980s. Several others have since been registered for broadleaf and grass weed control in cereals, corn, soybeans, rice, rangeland, and non-cropland.

Triflusulfuron is a new postemergence sulfonylurea herbicide for the control of broadleaf weeds and suppression of annual grass weeds in sugar beets (Kral et al., 1992). It has been reported to have a high degree of crop safety and weed efficacy in sugar beets, especially when tank mixed with desmedipham plus phenmedipham or desmedipham. (Allison et al., 1993; Dexter et al., 1993; Miller and Fornstrom, 1993; Morishita et al., 1992; Renner and Crook, 1993; Wilson, 1993).

The objectives of these experiments were to define the optimum rate and application timing of triflusulfuron for broadleaf weed control and compare the effectiveness of triflusulfuron applied alone, sequentially, and in tank mixture with other sugar beet herbicides for control of several broadleaf weeds.

MATERIALS AND METHODS

Field experiments were conducted near Kimberly and Parma, ID in 1991 and 1992. Soil type at Kimberly was a Portneuf silt loam (coarse-silty, mixed, mesic, Durixerollic Calciorthids) and a Greenleaf

silt loam (fine-silty, mixed, mesic Xerollic Haplagarids) at Parma. Soil pH was 8.0 and 7.8, organic matter 1.6 and 1.5%, and CEC was 15 and 21 meq/100 gm soil at each location each year. Experimental areas were fertilized according to University of Idaho soil test recommendations before planting sugar beets and during the growing season as needed. Sugar beet planting dates and other agronomic information are listed in Table 1. Row spacing was 56 cm and each plot was 4 rows wide and 9 m long. Plots were sprinkler irrigated as needed throughout the growing season.

Soil-applied and postemergence trials. Herbicides were applied with a hand-held or bicycle wheel sprayer pressurized with CO_2. Preplant incorporated (PPI) and preemergence (PRE) treatments were applied broadcast using 11002 flat fan nozzles calibrated to deliver 94 L/ha. All PPI treatments were incorporated immediately after application with a roller harrow set to incorporate the herbicide 5 cm. The implement was pulled two times across the treatments at a speed of 8 km/h. Postemergence (POST) applications were applied in a 25 cm band over the row with 8001 even fan nozzles calibrated to deliver 187 L/ha when the sugar beets were in the 2 leaf stage. Additional application information for these experiments is shown in Table 2.

Postemergence trials. All POST treatments were applied with a bicycle wheel sprayer pressurized with CO_2. Herbicides were applied in a 25 cm band over the row using 8001 even fan nozzles calibrated to deliver 187 L/ha when the sugar beets were in the cotyledon (COTYL) and 2 leaf (2-LF) stage. Weeds were in the cotyledon and 2 to 4 leaf growth stage when the sugar beets were in the COTYL and 2-LF growth stage, respectively. All POST treatments included a sequential application 7 days after the first application was made. Nonionic surfactant was added to triflusulfuron alone treatments at a rate of 0.25% v/v. Triflusulfuron plus desm & phen tank mixtures did not receive additional surfactant due to existing adjuvant in the desm & phen. Additional application information is shown in Table 3.

Table 1. Agronomic information for field experiments conducted near Parma and Kimberly, Idaho in 1991 and 1992.

	Parma		Kimberly	
Year	1991	1992	1991	1992
Sugar beet cultivar[†]	HH 32	MH RH 83	WS 88	WS 88
Planting date	April 8	April 1	April 18	April 19
Seeds/ha	176,061	156,499	176,061	117,374

[†] HH32 cultivar from Holly Sugar Corp., P.O. Box 60, Tracy, CA 95378. MH RH 83 and WS 88 cultivars from Hilleshog Mono-hy, 11939 Sugarmill Rd., Longmont, CO 80501.

Table 2. Preplant (PPI), preemergence (PRE), and postemergence (POST) application data in field experiments, near Parma and Kimberly, Idaho in 1991 and 1992.

	Parma					
Year	1991			1992		
Application type	PPI	PRE	POST	PPI	PRE	POST
Application date	4/1	4/9	5/10	3/31	4/3	4/28
Air temperature (C)	22	14	8	22	21	29
Soil temperature (C)	17	9	4	14	13	13
Relative humidity (%)	40	49	60	46	38	32

	Kimberly			
Year	1991		1992	
Application type	PPI/PRE	POST	PPI/PRE	POST
Application date	4/15	5/23	4/14	5/8
Air temperature (C)	13	22	18	23
Soil temperature (C)	13	16	13	18
Relative humidity (%)	54	41	41	49

Table 3. Application data for cotyledon (COTYL), 2 leaf (2-LF) and 7 days later (7d) applications near, Parma and Kimberly, Idaho in 1991 and 1992.

	Parma							
Year	1991				1992			
Application type	COTYL	7d	2-LF	7d	COTYL	7d	2-LF	7d
Application date	4/24	5/1	5/10	5/22	4/21	4/28	4/28	5/6
Air temperature (C)	13	21	8	27	12	29	29	33
Soil temperature (C)	14	13	4	22	13	20	20	28
Relative humidity (%)	70	18	60	40	100	32	32	28

	Kimberly							
Year	1991				1992			
Application type	COTYL	7d	2-LF	7d	COTYL	7d	2-LF	7d
Application date	5/10	5/16	5/23	5/31	5/5	5/12	5/8	5/14
Air temperature (C)	11	24	22	11	23	17	24	27
Soil temperature (C)	8	17	16	9	12	13	20	24
Relative humidity (%)	50	46	41	62	60	42	49	49

Crop injury and weed control were evaluated visually 2 and 4 weeks after the last herbicide treatment was applied. Crop injury and weed control were scored on a scale of 0 to 100 with 0 = no injury and 100 = complete kill. Sugar beets were cultivated two to three times beginning in May and were never hand weeded except for the hand weeded treatment. Growers often rely on hand weeding during the growing season, but the intent of these experiments was to evaluate the effect of these herbicides alone on weed control, sugar beet yield, and quality. Sugar beet roots were harvested at Kimberly from the center two rows of each plot. Subsamples were taken from each plot to determine sugar content. Plots were not harvested at Parma.

The experimental design for all studies was a randomized complete block with four replications. All data were subjected to analysis of variance procedures. Weed control data were transformed by arcsine and subjected to analysis of variance. Data from 1991 and 1992 were combined and where treatment by year interaction was significant, data from each year are presented separately. Transformation did not influence analysis of variance or mean separation for weed control data, so percentages are reported. Means were separated using Fisher's Protected LSD Test (P = 0.05).

RESULTS AND DISCUSSION

Soil-applied and postemergence trials. No differences in crop injury were found between years at either Parma or Kimberly. Sugar beets were injured at Parma by cycloate and diethatyl applied PPI and followed with a tank mixture of triflusulfuron + desmedipham and phenmedipham (desm & phen) POST, however the injury was less than 5% (data not shown).

Redroot pigweed control was evaluated only in 1991 at Parma and in both years at Kimberly (Table 4). Triflusulfuron applied sequentially to cycloate or ethofumesate did not improve redroot pigweed control. Redroot pigweed control improved 15 to 26% when diethatyl and triflusulfuron were applied sequentially compared to diethatyl alone. Soil-applied herbicides followed by triflusulfuron + desm & phen POST controlled redroot pigweed 90 to 100% at both locations. The triflusulfuron + desm & phen combination was significantly better than triflusulfuron alone applied sequentially to cycloate and ethofumesate.

Common lambsquarters control at Parma is presented by year due to a treatment by year interaction, and is combined over years for Kimberly (Table 4). Triflusulfuron improved common lambsquarters control 23 to 25% when applied sequentially to cycloate at Parma in

Table 4. Effect of herbicides applied preplant incorporated (PPI), preemergence (PRE) and postemergence (POST) on crop injury and weed control, near Parma and Kimberly, Idaho in 1991 and 1992.

			Weed control*				
			Redroot pigweed		C. lambsquarters		
			Parma	Kimberly	Parma		Kimberly
Treatment	Rate	Timing of Application	1991	Combined†	1991	1992	Combined
	kg ai/ha				%		
Check			0	0	0	0	0
Hand weeded			—	100	—	—	100
Cycloate	3.37	PPI	49	66	53	69	42
Cycloate/triflusulfuron§	2.25/0.02	PPI/POST	70	67	78	73	66
Cycloate/triflusulfuron+ desm & phen¶	2.25/0.02+0.37	PPI/POST	100	96	99	90	92
Diethatyl ethyl	3.37	PPI	49	73	53	3	43
Diethatyl ethyl/triflusulfuron	2.25/0.02	PPI/POST	75	87	71	19	66
Diethatyl ethyl/triflusulfuron +desm & phen	2.25/0.02+0.37	PPI/POST	90	98	89	75	87
Ethofumesate	1.26	PRE	68	66	59	21	51
Ethofumesate/triflusulfuron	0.84/0.02	PRE/POST	64	84	66	34	64
Ethofumesate/triflusulfuron + desm & phen	0.84/0.02+0.37	PRE/POST	91	98	90	80	91
LSD (0.05)			21	15	23	21	15

* Weed control was evaluated 3 to 4 weeks after last herbicide treatment was applied.
† Weed control data were combined for 1991 and 1992.
§ Nonionic surfactant added at a rate of 0.25% v/v to all triflusulfuron alone POST applications. R-11 Spreader Activator, Wilbur-Ellis Company, P.O Box 8838, Portland, OR 97208.
¶ Desm & phen = preformulated mixture of desmedipham and phenmedipham.

1991 and cycloate and diethatyl at Kimberly. Triflusulfuron + desm & phen in combination with all soil-applied treatments, except cycloate in both years and diethatyl in 1991, improved common lambsquarters control compared to triflusulfuron alone. The addition of desm & phen to triflusulfuron controlled common lambsquarters 80% or better with all soil-applied treatments except diethatyl in 1992.

Hairy nightshade control was evaluated at Parma only and the data were analyzed by year (Table 5). Hairy nightshade control with triflusulfuron applied sequentially to any soil-applied herbicide was no better than 78% with the exception of triflusulfuron following cycloate in 1992. Triflusulfuron + desm & phen following the soil-applied treatments controlled hairy nightshade an average of 90%.

Kochia control was evaluated at Kimberly only and the data were combined over years (Table 5). Triflusulfuron applied sequentially compared to the three soil-applied herbicides alone improved kochia control 32 to 49%. Tank mixing triflusulfuron and desm & phen further improved kochia control 51 to 67% compared to soil-applied alone.

Sugar beet yield data were analyzed by year (Table 5). Sugar content was not different among treatments in this study (data not shown). In 1991 sugar beet yield was not different in any of the soil-applied treatments alone or with triflusulfuron applied sequentially to cycloate and diethatyl compared to the check. Only diethatyl and ethofumesate followed by triflusulfuron + desm & phen had sugar beet yields equal to the hand weeded treatment. It is not known why sugar beets treated with cycloate followed by triflusulfuron + desm & phen did not yield as well as the other soil-applied treatments. In 1992, all plots treated with herbicides had higher root yields than the untreated check.

Postemergence trials. Crop injury was greatest when triflusulfuron + desm & phen was applied at 0.04 + 1.12 kg/ha at both locations (Table 6). Crop injury ranged from 1 to 36%.

Redroot pigweed control was evaluated at Parma only in 1991 and both years at Kimberly (Table 6). The Kimberly data were analyzed by year. Redroot pigweed control with desm & phen averaged 65% at Parma and 85 to 98% at Kimberly. Comparatively, redroot pigweed control was $\leq$ 71% when triflusulfuron alone was applied at COTYL or 2-LF at Parma and Kimberly. Triflusulfuron + desm & phen tank mix applications beginning at 2-LF at Parma and Kimberly controlled redroot pigweed better than or equal to tank mix applications beginning at COTYL. In 1991, redroot pigweed control at Parma was better with triflusulfuron + desm & phen tank mixtures applied at 2-LF compared to desm & phen alone. Redroot pigweed control with desm & phen at Kimberly was as good or better than other herbicide treatments

Table 5. Effect of herbicides applied preplant incorporated (PPI), preemergence (PRE) and postemergence (POST) on weed control 3 to 4 weeks after treatment and sugar beet yield and sugar content, near Parma and Kimberly, Idaho in 1991 and 1992.

			Weed control[†]				
			Parma			Kimberly	
			Hairy nightshade		Kochia	Root yield	
Treatment	Rate	Timing of application	1991	1992	Combined[‡]	1991	1992
	kg ai/ha		%			ton/ha	
Check			0	0	0	5	1
Hand weeded			——	——	100	42	62
Cycloate	3.37	PPI	51	78	18	2	12
Cycloate/triflusulfuron[§] +	2.25/0.02	PPI/POST	78	90	67	11	20
Cycloate/triflusulfuron + desm & phen[¶]	2.25/0.02+0.37	PPI/POST	100	94	85	22	29
Diethatyl ethyl	3.37	PPI	46	15	24	3	16
Diethatyl ethyl/triflusulfuron +	2.25/0.02	PPI/POST	73	53	61	7	16
Diethatyl ethyl/triflusulfuron + desm & phen	2.25/0.02+0.37	PPI/POST	91	79	78	39	21
Ethofumesate	1.26	PRE	60	18	37	8	12
Ethofumesate/triflusulfuron	0.84/0.02	PRE/POST	65	55	69	24	20
Ethofumesate/triflusulfuron ± desm & phen	0.84/0.02+0.37	PRE/POST	91	85	88	33	26
LSD (0.05)			21	23	16	11	10

[†] Weed control was evaluated 3 to 4 weeks after last herbicide treatment was applied.
[‡] Kochia control data were combined for 1991 and 1992.
[§] Nonionic surfactant added at a rate of 0.25% v/v to all triflusulfuron alone POST applications. R-11 Spreader Activator, Wilbur-Ellis Company, P.O Box 8838, Portland, OR 97208.
[¶] Desm & phen preformulated mixture of desmedipham and phenmedipham.

Table 6. Effect of herbicides on crop injury and weed control in sugar beets, near Parma and Kimberly, Idaho in 1991 and 1992.

			Crop injury					Weed control[†]					
						Redroot pigweed				C. lambsquarters			
			Parma		Kimberly	Parma		Kimberly		Parma		Kimberly	
Treatment	Rate	Timing of application[‡]	1991	1992	1991	1992	1991	1991	1992	1991	1992	1991	1992
	kg ai/ha		%										
Check			0	0	0	0	0	0	0	0	0	0	0
Hand weeded			—	—	0	0	—	100	100	—	—	100	100
Triflusulfuron[§]	0.02	COTYL & 7 d ltr	0	0	0	0	26	40	71	24	23	37	65
Triflusulfuron	0.02	2-LF & 7 d ltr	0	0	2	0	56	69	34	48	11	62	42
Triflusulfuron + desm & phen[¶]	0.01+0.37	COTYL & 7 d ltr	0	3	1	1	67	79	99	79	90	81	87
Triflusulfuron + desm & phen	0.01+0.37	2-LF & 7 d ltr	2	1	1	0	93	96	100	92	86	96	95
Triflusulfuron + desm & phen	0.01+0.56	COTYL & 7 d ltr	—	—	2	6	—	91	100	—	—	96	100
Triflusulfuron + desm & phen	0.01+0.56	2-LF & 7 d ltr	—	—	6	0	—	98	98	—	—	99	94
Triflusulfuron + desm & phen	0.02+0.37	COTYL & 7 d ltr	0	3	0	2	67	86	100	71	91	89	98
Triflusulfuron + desm & phen	0.02+0.37	2-LF & 7 d ltr	0	5	0	0	92	99	97	92	93	98	91
Triflusulfuron + desm & phen	0.02+0.56	COTYL & 7 d ltr	1	1	0	6	73	81	100	78	96	88	97
Triflusulfuron + desm & phen	0.02+0.56	2-LF & 7 d ltr	3	3	0	0	91	100	98	94	97	100	100
Triflusulfuron + desm & phen	0.04+1.12	COTYL & 7 d ltr	1	3	4	16	79	94	100	80	97	94	100
Triflusulfuron + desm & phen	0.04+1.12	2-LF & 7 d ltr	36	20	19	6	100	100	100	100	100	99	100
Desm & phen	0.37	COTYL & 7 d ltr	0	1	0	3	65	85	98	71	94	92	100
LSD (0.05)			4	8	5	6	21	13	20	18	16	12	16

[†] Weed control was evaluated 2 to 3 weeks after last herbicide treatment was applied.
[‡] COTYL = cotyledon, 7 d ltr = 7 days later and 2-LF = 2 leaf.
[§] Nonionic surfactant added at a rate of 0.25% v/v to all triflusulfuron alone POST applications. R-11 Spreader Activator, Wilbur-Ellis Company, P.O Box 8838, Portland, OR 97208.
[¶] Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 7. Effect of herbicides on weed control, and sugar beet yield, near Parma and Kimberly, Idaho in 1991 and 1992.

Treatment	Rate	Timing of application‡	Weed control†			Kimberly root yield	
			Hairy nightshade		Kochia		
			1991	1992	Combined§	1991	1992
	kg ai/ha		%			ton/ha	
Check			0	0	0	5	15
Hand weeded					100	68	51
Triflusulfuron¶	0.02	COTYL & 7 d ltr	24	23	79	22	36
Triflusulfuron	0.02	2-LF & 7 d ltr	49	9	76	20	29
Triflusulfuron + desm & phen#	0.01+ 0.37	COTYL & 7 d ltr	72	86	88	34	35
Triflusulfuron + desm & phen	0.01+0.37	2-LF & 7 d ltr	95	70	90	40	40
Triflusulfuron + desm & phen¶	0.01+ 0.56	COTYL & 7 d ltr	—	—	93	45	31
Triflusulfuron + desm & phen	0.01+ 0.56	2-LF & 7 d ltr	—	—	93	40	32
Triflusulfuron + desm & phen	0.02+ 0.37	COTYL & 7 d ltr	64	90	92	40	44
Triflusulfuron + desm & phen	0.02+ 0.37	2-LF & 7 d ltr	91	63	90	47	34
Triflusulfuron + desm & phen	0.02+ 0.56	COTYL & 7 d ltr	70	85	93	40	40
Triflusulfuron + desm & phen	0.02+ 0.56	2-LF & 7 d ltr	87	82	95	43	34
Triflusulfuron + desm & phen	0.04+ 1.12	COTYL & 7 d ltr	74	93	98	52	22
Triflusulfuron + desm & phen	0.04+ 1.12	2-LF & 7 d ltr	100	100	97	48	31
Desm & phen	0.37	COTYL & 7 d ltr	70	81	81	38	21
LSD (0.05)			19	17	4	10	12

† Weed control was evaluated 2 to 3 weeks after last herbicide treatment was applied.
‡ COTYL = cotyledon, 7 d ltr = 7 days later and 2-LF = 2 leaf.
§ Kochia control data were combined for 1991 and 1992.
¶ Nonionic surfactant added at a rate of 0.25• v/v to all triflusulfuron alone POST applications. R-11 Spreader Activator, Wilbur-Ellis Company, P.O Box 8838, Portland, OR 97208.
Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Common lambsquarters control data were analyzed by year at both locations (Table 6). Desmedipham and phenmedipham alone control of common lambsquarters ranged from 71 to 100%. Common lambsquarters control with triflusulfuron alone at Parma and Kimberly ranged from only 11 to 65% over both years regardless of application timing. In 1991, triflusulfuron + desm & phen applied at 2-LF controlled common lambsquarters better than desm & phen alone. However, desm & phen alone was equal to all triflusulfuron + desm & phen treatments and superior to triflusulfuron alone at Kimberly in both years and Parma in 1992.

Hairy nightshade control was evaluated at Parma only and averaged 70 to 81% with desm & phen in 1991 and 1992, respectively (Table 7). Triflusulfuron alone did not control hairy nightshade in either year. Triflusulfuron + desm & phen applied at 2-LF controlled hairy nightshade equal to or better than COTYL applications including desm & phen alone in 1991 and 1992. The only exception was triflusulfuron + desm & phen at 0.02 + 0.37 kg/ha in 1992.

Data were combined over years for kochia control which was evaluated only at Kimberly (Table 6). Desmedipham and phenmedipham alone controlled kochia 81% while kochia control with triflusulfuron alone ranged from 76 to 79%. All of the tank mix treatments controlled kochia 88 to 98% and this was significantly better than desmedipham and phenmedipham alone. As mentioned previously, kochia is considered one of the most difficult weeds to control in sugar beets.

Sugar beet yield data were analyzed by year (Table 7). In 1991, desm & phen alone had sugar beet yields higher than triflusulfuron alone and equal to all triflusulfuron + desm & phen treatments except triflusulfuron + desm & phen at 0.04 + 1.12 kg/ha. In 1992, six tank mix combinations had sugar beet yields greater than desm & phen alone. Triflusulfuron alone treatments had sugar beet yields 14 to 32 ton/ha less than all tank mix treatments in 1991, but were comparable in 1992. None of the tank mix treatments yielded differently between COTYL and 2-LF applications. Sugar content was not affected by any treatment in this study (data not shown).

These experiments have shown that triflusulfuron is a potentially important new chemical for weed control in sugar beets. Following a soil-applied herbicide, triflusulfuron alone did not control redroot pigweed, common lambsquarters, hairy nightshade, or kochia as effectively as triflusulfuron + desm & phen tank mixtures. Without soil-applied herbicides, weed control with triflusulfuron + desm & phen combinations was better than triflusulfuron alone. Compared to desm & phen alone, the tank mixture improved the consistency of weed

control and controlled weeds at a later sugar beet growth stage which corresponded to larger weeds. Sugar beets appear to be very tolerant to triflusulfuron at rates where weed control remains efficacious. Weed control with triflusulfuron + phen & desm at 0.01 + 0.37 kg/ha was as effective as the higher rates used. The effectiveness of triflusulfuron for controlling kochia in these experiments demonstrates the benefit of this herbicide.

LITERATURE CITED

Allison, D.A., T.S. Ulrich, W.S. Wilms, J.L. Pacheco, G.L. Leek, J.P. Claude, and K. Graham. 1993. DPX-66037- review of results in sugar beet from U.S. and France. Abstr. 26th Bienn. Meeting J. Sugar Beet Res. 30:80.

Beyer, E.M., J.J. Duffy, J.V. Hay and D.D. Schlueter. 1988. Sulfonylureas. pp. 117-189. *In* P.C. Kearney and D.D. Kaufman (ed). Herbicides: Chemistry, degradation, and mode of action. Marcel Dekker, New York.).

Bridges, D.C., editor. Crop losses due to weeds in the United States; 1992; 403 p. Available from Weed Science Society of America, Champaign, IL.

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

Dexter, A.G. J.L. Luecke, and M.W. Bredehoeft. 1993. Postemergence control of broadleaf weeds. Abstr. 26th Bienn. Meeting. J. Sugar Beet Res. 30:88.

Kral, C.W., J.L. Saladini, W.C. Wilms, and J.L. Pacheco. 1992. A new sulfonylurea herbicide for postemergence weed control in sugarbeets. Proc. West. Soc. Weed Sci. 45:84

Miller, S.D. and K. J. Fornstrom. 1993. Postemergence herbicide timing and combinations in sugarbeets. Abstr. 26th Bienn. Meeting. J. Sugar Beet Res. 30:109.

Morishita, D.W., R.W. Downard, C.E. Stanger, C.W. Kral, R. Leavitt, and J.L. Pacheco. 1992. DPX-66037 for weed control in sugarbeets. Proc. West. Soc. Weed Sci. 45:84.

Renner, K.A. and T.M. Crook. 1993. Postemergence weed control in sugarbeets with DPX-66037 in Michigan. Abstr. 26th Bienn. Meeting. J. Sugar Beet Res. 30:113.

Schweizer, E.E. 1973. Predicting sugar beet root losses based on kochia densities. Weed Sci. 21:565-567.

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

Schweizer, E.E. 1981. Broadleaf weed interference in sugarbeets *(Beta vulgaris).* Weed Sci. 29:128-133.

Schweizer, E.E. 1983. Common lambsquarters *(Chenopodium album)* interference in sugarbeets *(Beta vulgaris).* Weed Sci. 31:5-8.

Schweizer, E.E. and L.D. Bridge. 1982. Sunflower *(Helianthus annuus)* and velvetleaf *(Abutilon theophrasti)* interference in sugarbeets *(Beta vulgaris).* Weed Sci. 30:514-519.

Schweizer, E.E. and T.C. Lauridson. 1985. Powell amaranth *(Amaranthus powellii)* interference in sugar beet *(Beta vulgaris).* Weed Sci. 33:518-520.

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

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

Wilson, R.G. 1993. Weed and sugar beet response to postemergence applications of DPX-66037, clopyralid, ethofumesate, and desmedipham plus phenmedipham. Abstr. 26th Bienn. Meeting. J. Sugar Beet Res. 30:122.