Interaction Between Triflusulfuron and Organophosphate or Carbamate Insecticides in Sugarbeet

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ABSTRACT

Field experiments were conducted in Idaho, Nebraska, and North Dakota to evaluate interactions between postemergence applications of the herbicides triflusulfuron, and a premix of desmedipham plus phenmedipham (1:1 ratio) with at-planting applications of the insecticides terbufos, aldicarb, chlorpyrifos or chlorpyrifos applied postemergence in sugarbeet (*Beta vulgaris* L). In North Dakota, banding terbufos 15G or chlorpyrifos 15G at planting reduced injury from postemergence herbicides as compared to modified in-furrow (MIF) insecticide plus postemergence herbicides. Triflusulfuron gave less sugarbeet injury than triflusulfuron plus desmedipham and phenmedipham when applied to sugarbeet previously treated with insecticide. Terbufos 20CR in combination with postemergence herbicides had greater crop safety than terbufos 15G. In Nebraska, terbufos 15G and chlorpyrifos 15G at-planting plus triflusulfuron postemergence gave less injury compared to at-planting insecticides plus desmedipham and phenmedipham alone or in combination with triflusulfuron. Chlorpyrifos applied postemergence after herbicide application increased sugarbeet injury compared to chlorpyrifos applied postemergence alone. Triflusulfuron or desmedipham and phenmedipham ap-

plied to sugarbeet previously treated with an insecticide gave less injury than desmedipham and phenmedipham plus triflusulfuron. In Idaho, injury increased when triflusulfuron was applied after aldicarb or terbufos compared to insecticides alone. At all three locations, herbicide-insecticide combinations had little or no effect on percent sugar content of harvested roots.

Additional Key Words: triflusulfuron, desmedipham, phenmedipham, terbufos, aldicarb, chlorpyrifos.

Herbicides and insecticides are commonly applied in the same growing season for the control of weed and insect pests in a sugarbeet (*Beta vulgaris* L.) crop. Antagonistic interactions between herbicides and insecticides can reduce sugarbeet yields. Carbamates and organophosphates are two classes of insecticides used in many crops and have been studied in conjunction with herbicides.

Interactions among herbicides and organophosphate or carbamate insecticides have produced variable results. Phorate and trifluralin combinations did not reduce cotton (*Gossypium hirsutum*) germination (Arle, 1968, Hassaway and Hamilton, 1971). However, dry shoot weight was less with the combination than with either product alone. Cotton height was reduced when diuron or monuron herbicides were applied in combination with disulfoton insecticide compared to herbicide or insecticide alone (Hacskaylo et al., 1964). Prometryn uptake in black beans (*Phaseolus vulgaris* L.) increased when phorate was present resulting in increased phytotoxicity from prometryn (Parks et al., 1972). Other data have shown reduced soybean yields when terbufos, an organophosphate, or phorate, a carbamate, were followed by preemergence (PRE) metribuzin as compared to insecticides used alone (Hayes et al., 1979, Waldrop and Banks, 1983). In contrast, soybean (*Glycine max* L.) yields were not affected when terbufos was applied at-planting and acifluorfen applied postemergence (POST).

New sulfonylurea herbicides developed for use in corn (*Zea mays* L.) and cotton have the potential for phytotoxic interactions with organophosphate and carbamate insecticides. Nicosulfuron reduced corn height and caused some malformation of corn plants, however, corn populations were not affected. At-planting terbufos applications followed by nicosulfuron injured corn and reduced corn population and grain yield compared to corn treated with nicosulfuron only (Kapusta and Krausz 1992; Morton et al., 1991). Primisulfuron, another sulfonylurea herbicide, significantly injured corn and reduced yield when applied POST following terbufos at-planting (Biediger et al., 1992). In contrast, DPX-PE350, a

new POST herbicide for cotton did not interact with in-furrow applications of aldicarb, disulfoton, or phorate (Jordan et al., 1993). The response of individual crops to specific herbicide-insecticide interactions must be determined.

Sugarbeet response to herbicide and insecticide interactions have been documented for responses in sugarbeet. Cycloate herbicide and aldicarb insecticide together did not reduce root or shoot fresh weight in sugarbeet compared to cycloate alone (Abivardi and Altman, 1978). Similarly, EPTC applied preplant incorporated (PPI) or POST desmedipham herbicide applications did not reduce sugar yield or sucrose content when combined with aldicarb at-planting when compared to these herbicides used alone (Cole and Dexter, 1985). However, cycloate or pyrazon in combination with phorate reduced sugarbeet emergence and stands when compared to herbicides used alone (Lee et al., 1969). A combination of disulfoton and cycloate increased crop injury but did not reduce root or sucrose yield compared to the insecticide or herbicide alone (Wedderburn et al., 1973).

Research has shown that organophosphate insecticides can reduce sugarbeet stand and plant vigor more than carbamate insecticides (Wilson and Hein, 1991). However, these effects were not severe enough to significantly reduce sucrose content or root yield.

Triflusulfuron is a sulfonylurea herbicide for selective control of annual weeds in sugarbeet. Insecticides commonly used in sugarbeet include aldicarb a carbamate, and terbufos and chlorpyrifos two organophosphate insecticides. The objective of this study was to determine if triflusulfuron applied POST alone or in combination with desmedipham and/or phenmedipham to cotyledon and two-leaf sugarbeet would interact with aldicarb, terbufos, or chlorpyrifos to increase injury or reduce sugarbeet root yield or quality.

MATERIALS AND METHODS

Field experiments were conducted at Kimberly, ID, Scottsbluff, NE, and Saint Thomas, ND in 1992, 1993, and 1994. Each experiment was designed to use pesticides and practices common to each area.

The soil type in Idaho was a silt loam with pH 8.0 and 1.9% organic matter. The experimental design in Idaho was a 2 by 3 factorial randomized complete block with four replicates. The herbicide treatments were triflusulfuron applied sequentially at 0.018 and 0.035 kg ai/ha and an untreated check. The insecticide treatments were aldicarb at 2.2 kg ai/ha, terbufos 15G, and 20CR (1993 only) at 2.0 kg ai/ha and an untreated check. Plots were four rows wide by 9.1 m long with a 0.6 m row spacing. The two center rows of each plot were harvested. Insecticides were applied at-

planting using a modified in-furrow (MIF) placement where the insecticide was deposited immediately in front of the press wheel and a chain behind the press wheel incorporated the insecticide. Herbicides were applied in a 25-cm band with CO_2-pressurized a hand-held or bicycle wheel sprayer. All treatments were applied in 187 L/ha of water at 262 kPa using 8001 even fan nozzles when the sugarbeet were in the cotyledon and two-leaf stage. Additional application information is presented in Table 1.

Table 1. Environmental conditions for herbicide application at Idaho, Nebraska, and North Dakota.

Location	Year	Planting Date	Application Date	Air Temperature	Wind Speed	Harvest Date
				Celsius	k/hr	
Idaho	1992	4/20	5/20	19	16	9/28
			5/27	17	19	
	1993	4/20	5/19	23	20	9/30
			5/27	27	6	
Nebraska	1993	5/5	5/12	13	14	10/23
			5/18	13	5	
	1994	5/4	5/17	22	8	10/8
			5/23	21	6	
North Dakota	1993	4/21	5/25	17	21	9/27
			6/1	18	5	
	1994	4/15	5/26	22	8	9/23
			6/2	26	32	

All plots were maintained weed free by cultivation and hand-weeding throughout the growing season to eliminate weed interference.

In Nebraska, the soil was a sandy loam with pH 8.1 and 0.9% organic matter. The experimental design was a split block with four replicates. The main plots were herbicide treatments, which included an untreated check and sequential applications of desmedipham & phenmedipham

at 0.37 kg ai/ha and triflusulfuron at 0.018 kg ai/ha, applied alone or in combination. The subplots were insecticide treatments, which were PPI terbufos at 2 or 4 kg ai/ha, PPI chlorpyrifos 15G at 2.25 or 4.5 kg ai/ha, POST chiorpyrifos 4E at 1.08 or 2.25 kg ai/ha, and PPI aldicarb applied at 2.25 or 4.4 kg ai/ha. Plots were two rows wide by 7.62 m long. Insecticides were applied in a 18-cm band behind the planter and incorporated with a drag chain. Herbicides were applied with a tractor-mounted sprayer at 196 L/ha and 248 kPa using 11002 nozzles when sugarbeet was in the cotyledon to two-leaf stage. Additional application information is shown in Table 1. Plots were cultivated and hand weeded to reduce weed interference.

The soil type in North Dakota was a loam with a pH of 7.8 and 3.8% organic matter. The experimental design was a randomized complete block with four replicates. Plots were six rows wide by 10.6 m long. Herbicide treatments included an untreated check, sequential applications of desmedipham and phenmedipham at 0.37 kg ai/ha and triflusulfuron at 0.018 kg ai/ha, applied alone or in combination. The insecticide treatments were terbufos 15G at 2.0 kg ai/ha, terbufos 20CR at 2.0 kg ai/ha, and chlorpyrifos at 2.26 kg ai/ha. Insecticides were applied in a band or MIF at-planting. Herbicides were applied at 79 L/ha and 276 kPa when sugarbeet was at the cotyledon to two-leaf stage. Additional application information is presented in Table 1. The four inside rows were sprayed with herbicides and the two center rows were harvested. Plots were cultivated and hand-weeded to reduce weed interference.

Sugarbeet populations were determined by counting 15 meters in a row. Visual ratings based on a percentage are how injury was measured. A zero percent indicated no injury and one hundred percent indicated completely dead plants.

At all locations, sugarbeet roots from each plot were tested for sucrose and extractable sugar.

RESULTS AND DISCUSSION

At Kimberly, Idaho aldicarb did not adversely affect sugarbeet stands in 1992 or 1993 (Tables 2 and 3). In 1992, plots treated with terbufos had fewer sugarbeet plants than aldicarb treated or untreated plots (Table 2). In 1993, no treatment significantly reduced sugarbeet stands and the data is not shown.

Sugarbeet injury was more pronounced in 1992 than in 1993 (Tables 2 and 3). In 1992 on May 29 the treatments which had significantly higher injury ratings than the untreated check were, triflusulfuron at 0.035 kg ai/ha, triflusulfuron at 0.018 kg ai/ha and 0.035kg ai/ha applied

Table 2. Sugarbeet population, crop injury, root yield, and sucrose near Kimberly, Idaho, 1992.

Herbicide		Insecticide		Sugarbeet					
					Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Population	5/29	6/9	Yield	Content	Sucrose
	kg/ha		kg/ha	plts/15 m	—— % ——		tons/ha	%	kg/ha
None	None			70	0	3	70	18.1	9670
Triflusulfuron	0.018	none		—	4	1	70	17.8	9400
Triflusulfuron	0.035	none		—	11	6	75	17.2	10040
None		terbufos	2.0	50	0	10	75	16.5	9690
Triflusulfuron	0.018	terbufos	2.0	—	15	6	60	17.4	8060

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicides were applied sequentially at the cotyledon and two-leaf growth stage.

Table 2. (Continued)

Herbicide		Insecticide		Sugarbeet					
					Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Population	5/29	6/9	Yield	Content	Sucrose
	kg/ha		kg/ha	plts/15 m	—— % ——		tons/ha	%	kg/ha
Triflusulfuron	0.035	terbufos	2.0	—	18	9	70	17.8	9830
None		aldicarb	2.2	78	0	1	80	17.3	10080
Triflusulfuron	0.018	aldicarb	2.2	—	14	3	75	16.3	9020
Triflusulfuron	0.035	aldicarb	2.2	—	9	4	70	17.6	9840
LSD (0.05)				10	7	NS	NS	NS	NS

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicides were applied sequentially at the cotyledon and two-leaf growth stage.

Table 3. Sugarbeet stand, crop injury, and root yield near Kimberly, Idaho, 1993.

Herbicide		Insecticide		Sugarbeet				
				Population	Injury	Root	Sucrose	Extractable
Treatment†	Rate	Treatment	Rate	6/10	6/21	Yield	Content	Sucrose
	kg/ha		kg/ha	plts/15 m	%	tons/ha	%	kg/ha
None		none		81	0	55	17.5	7550
Triflusulfuron	0.018	none		75	3	57	17.4	7755
Triflusulfuron	0.035	none		86	0	58	17.5	7945
None		terbufos 15G	2.0	58	3	58	17.4	7890
Triflusulfuron	0.018	terbufos 15G	2.0	88	1	67	17.6	9330
Triflusulfuron	0.035	terbufos 15G	2.0	79	0	60	17.4	8100
None		terbufos 20CR	2.0	58	0	61	17.6	8445

†Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicides were applied sequentially at the cotyledon and two-leaf growth stage.

Table 3. (Continued)

Herbicide		Insecticide		Sugarbeet				
				Population	Injury	Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	6/10	6/21	Yield	Content	Sucrose
	kg/ha		kg/ha	plts/15 m	%	tons/ha	%	kg/ha
Triflusulfuron	0.018	terbufos 20CR	2.0	79	0	54	17.7	7600
Triflusulfuron	0.035	terbufos 20CR	2.0	88	1	67	17.6	9185
None		aldicarb	2.2	77	0	59	17.4	8075
Triflusulfuron	0.018	aldicarb	2.2	73	0	61	17.6	8430
Triflusulfuron	0.035	aldicarb	2.2	84	0	63	17.2	8495
LSD (0.05)				NS	NS	NS	NS	NS

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicides were applied sequentially at the cotyledon and two-leaf growth stage.

after terbufos, and triflusulfuron at 0.018 kg ai/ha applied after aldicarb (Table 2). On June 9 no treatment had significantly higher injury than the untreated check. Weather in 1992 was dryer than in 1993. Terbufos is less active when soil moisture is low and this may have contributed to the differences in injury between 1992 and 1993 (Chapman and Harris, 1980). Sugarbeet overcame this initial injury and no significant damage was visible later in the season. No deleterious affect was measured for sugarbeet root yield or quality. Crop injury in 1993 was not significant for any treatment.

Sugarbeet root yield, sucrose content and extractable sucrose was not reduced by at-planting applications of terbufos or aldicarb alone or when followed by sequential applications of triflusulfuron in either year (Table 2 and 3).

In 1993 at St. Thomas, North Dakota, POST herbicides following MIF insecticides injured sugarbeet more than herbicides following band-applied insecticides at the June 12 evaluation, except for terbufos 20CR alone or followed by triflusulfuron at 0.018 and 0.035 kg ai/ha (Table 4). Terbufos 15G and chlorpyrifos 15G applied MIF followed by triflusulfuron plus desmedipham and phenmedipham caused the most sugarbeet injury. The addition of desmedipham and phenmedipham to triflusulfuron increased sugarbeet injury, but did not affect yield or quality. Injury was due to the herbicides since sugarbeet treated with insecticides had little or no injury except for chlorpyrifos.

Sugarbeet stand counts taken before and after thinning were lower in plots treated with MIF terbufos plus triflusulfuron alone at 0.035 kg ai/ha or triflusulfuron plus desmedipham and phenmedipham as compared to plots receiving band-applied terbufos plus the same herbicides. Plots treated with triflusulfuron at 0.035 kg ai/ha had lower sucrose content and lower yields. Triflusulfuron plus desmedipham and phenmedipham following insecticides applied MIF or banded resulted in the highest yields. These treatments resulted in higher sugarbeet extractable sucrose.

In 1994, triflusulfuron plus desmedipham and phenmedipham following any insecticide injured the crop more than most other treatments (Table 5). However, these combinations did not reduce sugarbeet yield and quality compared to the other treatments. Sugarbeet stands were lower in plots treated with MIF than in plots treated with banded chlorpyrifos before and after thinning (Table 5). The lower plant populations did not significantly affect sugarbeet yield or quality. Plots treated with MIF terbufos 15G and no herbicide or MIF chlorpyrifos plus triflusulfuron at 0.018 kg ai/ha were among the highest yielding plots. Only plots treated with triflusulfuron alone had root yields and extractable sucrose yields less

Table 4. Sugarbeet population, crop injury, root yield, and sucrose near St.Thomas, North Dakota, 1993.

Herbicide		Insecticide		Application	Sugarbeet					
					Population		Injury	Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method[‡]	6/14	9/27	6/12	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		%	tons/ha	%	kg/ha
None		none			93	41	0	22	16.4	2875
Triflusulfuron	0.018	none			109	34	3	17	16.2	2130
Triflusulfuron	0.035	none			112	31	5	14	15.6	1800
Desm & phen [§] + triflusulfuron	0.37 + 0.018	none			91	35	18	24	16.7	3150
None		terbufos 15G	2.0	MIF	85	40	4	19	16.9	2615
None		terbufos 15G	2.0	Band	92	47	0	23	16.7	3126

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicides were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]MIF = modified-in-furrow placement.
[§]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 4. (Continued)

Herbicide		Insecticide		Application	Sugarbeet					
					Population		Injury	Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method[‡]	6/14	9/27	6/12	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		%	tons/ha	%	kg/ha
Triflusulfuron	0.018	terbufos 15G	2.0	MIF	96	44	15	22	16.9	3105
Triflusulfuron	0.018	terbufos 15G	2.0	Band	94	53	3	33	17.3	4645
Triflusulfuron	0.035	terbufos 15G	2.0	MIF	66	32	28	20	16.9	2745
Triflusulfuron	0.035	terbufos 15G	2.0	Band	100	45	15	25	17.2	3550
Desm & phen + triflusulfuron	0.37 + 0.018	terbufos 15G	2.0	MIF	69	39	33	33	16.7	4405
Desm & phen + triflusulfuron	0.37 + 0.018	terbufos 15G	2.0	Band	103	54	15	36	17.2	5010

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicides were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]MIF = modified-in-furrow placement.
[§]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 4. (Continued)

Herbicide		Insecticide		Application	Sugarbeet					
					Population		Injury	Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method[‡]	6/14	9/27	6/12	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		%	tons/ha	%	kg/ha
None		terbufos 20CR	2.0	MIF	102	48	0	24	16.9	3290
None		terbufos 20CR	2.0	Band	98	45	0	20	17.1	2815
Triflusulfuron	0.018	terbufos 20CR	2.0	MIF	98	52	10	30	17.1	4180
Triflusulfuron	0.018	terbufos 20CR	2.0	Band	100	51	4	31	16.9	4250
Triflusulfuron	0.035	terbufos 20CR	2.0	MIF	93	42	5	19	16.7	2555
Triflusulfuron	0.035	terbufos 20CR	2.0	Band	102	47	9	29	17.0	3940
Desm & phen + triflusulfuron	0.37 + 0.018	terbufos 20 CR	2.0	MIF	107	55	33	41	17.3	5735

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicides were applied sequentially at the cotyledon and two-leaf growth stage.

[‡]MIF = modified-in-furrow placement.

[§]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 4. (Continued)

Herbicide		Insecticide		Application	Sugarbeet					
					Population		Injury	Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method[‡]	6/14	9/27	6/12	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		%	tons/ha	%	kg/ha
Desm & phen + triflusulfuron	0.37 + 0.018	terbufos 20CR	2.0	Band	101	53	15	33	16.7	4405
None		chlopyrifos 15G	2.26	MIF	92	41	18	24	17.0	3270
None		chlorpyrifos 15G	2.26	Band	99	41	0	19	16.7	2560
Triflusulfuron	0.018	chlorpyrifos 15G	2.26	MIF	93	44	30	26	17.3	3670
Triflusulfuron	0.018	chlorpyrifos 15G	2.26	Band	107	49	9	25	17.0	3400

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicides were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]MIF = modified-in-furrow placement.
[§]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 4. (Continued)

Herbicide		Insecticide		Application	Sugarbeet					
					Population		Injury	Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method[‡]	6/14	9/27	6/12	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		%	tons/ha	%	kg/ha
Triflusulfuron	0.035	chlorpyrifos 15G	2.26	MIF	102	48	21	27	17.0	3725
Triflusulfuron	0.035	chlorpyrifos 15G	2.26	Band	102	47	10	27	16.9	3675
Desm & phen + triflusulfuron	0.37 + 0.018	chlorpyrifos 15G	2.26	MIF	97	54	31	36	17.3	5110
Desm & phen + triflusulfuron	0.37 + 0.018	chlorpyrifos 15G	2.26	Band	101	53	16	33	17.2	4625
LSD (0.05)					20	10	8	8	0.8	1070

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicides were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]MIF = modified-in-furrow placement.
[§]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 5. Sugarbeet population, crop injury, root yield, and sucrose near St. Thomas, North Dakota 1994.

Herbicide		Insecticide		Application	Sugarbeet					
					Population		Injury	Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method[‡]	6/14	9/27	6/12	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		%	tons/ha	%	kg/ha
None		None			125	54	0	51	14.0	5665
Triflusulfuron	0.018	None			120	48	0	43	13.2	4415
Triflusulfuron	0.035	None			126	53	0	42	13.6	4515
Desm & phen [§]+ triflusulfuron	0.37 + 0.018	None			120	48	6	47	13.5	4995
None		terbufos 15G	2.0	MIF	112	58	0	56	13.8	6130
None		terbufos 15G	2.0	Band	120	58	0	48	14.0	5390

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]MIF = modified-in-furrow placement.
[§]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 5. (Continued)

Herbicide		Insecticide		Application	Sugarbeet					
					Population		Injury	Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method[‡]	6/14	9/27	6/12	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		%	tons/ha	%	kg/ha
Triflusulfuron	0.018	terbufos 15G	2.0	MIF	109	56	0	54	14.2	6255
Triflusulfuron	0.018	terbufos 15G	2.0	Band	112	56	0	53	14.1	6060
Triflusulfuron	0.035	terbufos 15G	2.0	MIF	112	61	1	54	14.5	6340
Triflusulfuron	0.035	terbufos 15G	2.0	Band	116	56	4	47	14.2	5455
Desm & phen + triflusulfuron	0.37 + 0.018	terbufos 15G	2.0	MIF	104	53	16	50	14.1	5730
Desm & phen + triflusulfuron	0.37 + 0.018	terbufos 15G	2.0	Band	121	52	13	50	14.5	5815

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]MIF = modified-in-furrow placement.
[§]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 5. (Continued)

Herbicide		Insecticide		Application	Sugarbeet					
					Population		Injury	Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method[‡]	6/14	9/27	6/12	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		%	tons/ha	%	kg/ha
None		terbufos 20CR	2.0	MIF	124	59	0	52	14.6	6100
None		terbufos 20CR	2.0	Band	119	55	0	51	14.1	5870
Triflusulfuron	0.018	terbufos 20CR	2.0	MIF	118	52	0	48	14.1	5495
Triflusulfuron	0.018	terbufos 20CR	2.0	Band	115	54	1	50	14.4	5805
Triflusulfuron	0.035	terbufos 20CR	2.0	MIF	113	51	1	50	15.0	6150
Triflusulfuron	0.035	terbufos 20CR	2.0	Band	118	56	1	51	14.2	5900
Desm & phen + triflusulfuron	0.37 + 0.018	terbufos 20CR	2.0	MIF	116	56	13	53	14.1	6000

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]MIF = modified-in-furrow placement.
[§]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 5. (Continued)

Herbicide		Insecticide		Application	Sugarbeet					
					Population		Injury	Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method[‡]	6/14	9/27	6/12	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		%	tons/ha	%	kg/ha
Desm & phen + triflusulfuron	0.37 + 0.018	terbufos 20CR	2.0	Band	120	51	9	47	14.1	5365
None		chlorpyrifos 15G	2.26	MIF	97	47	3	52	14.4	5995
None		chlorpyrifos 15G	2.26	Band	117	56	0	49	14.1	5630
Triflusulfuron	0.018	chlorpyrifos 15G	2.26	MIF	102	51	11	57	14.2	6485
Triflusulfuron	0.018	chlorpyrifos 15G	2.26	Band	121	58	3	53	14.3	6105
Triflusulfuron	0.035	chlorpyrifos 15G	2.26	MIF	95	47	15	54	14.1	6160

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]MIF = modified-in-furrow placement.
[§]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 5. (Continued)

Herbicide		Insecticide		Application	Sugarbeet					
					Population		Injury	Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method[‡]	6/14	9/27	6/12	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		%	tons/ha	%	kg/ha
Triflusulfuron	0.035	chlorpyrifos 15G	2.26	Band	119	53	3	50	14.6	5975
Desm & phen + triflusulfuron	0.37 + 0.018	chlorpyrifos 15G	2.26	MIF	103	51	21	56	14.1	6285
Desm & phen + triflusulfuron	0.37 + 0.018	chlorpyrifos 15G	2.26	Band	114	57	15	54	14.4	6260
LSD (0.05)					13	5	4	7.0	0.7	855

[†]Surfactant was added to all triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]MIF = modified-in-furrow placement.
[§]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

than the untreated check. This was due in part to the reduced yield from insect injury.

At Scottsbluff, Nebraska sugarbeet injury was similar among treatments on May 25, 1993 (Table 6). Injury ranged from 0 to 19% and injury tended to be greater from terbufos PPI or chlorpyrifos 4E POST followed by desmedipham and phenmedipham or desmedipham and phenmedipham plus triflusulfuron than from other treatments. These treatments also gave greater sugarbeet injury than most other treatments on June 8. No treatment reduced sugarbeet stands on May 25 or June 9. Even though sugarbeet injury was observed, root yield, sugar content, and extractable sucrose were not significantly reduced.

In 1994, crop injury was more pronounced among treatments and ranged from 1 to 20% over both evaluation dates. (Table 7). On the June 1 evaluation, PPI chlorpyrifos 15G followed by POST desmedipham & phenmedipham plus triflusulfuron or POST chlorpyrifos 4E followed by POST triflusulfuron were among the most injurious treatments. However, sugarbeet root yield and quality were not affected.

Two of the highest yielding treatments were PPI aldicarb at 2.25 kg ai/ha followed by POST desmedipham and phenmedipham plus triflusulfuron or PPI terbufos at 2.0 kg ai/ha followed by POST triflusulfuron. Sugar content was similar among treatments. Banding increased crop safety for terbufos and chlorpyrifos when compared to modified in furrow applications. Triflusulfuron was safer to sugarbeet than desmedipham and phenmedipham or the combination of the two.

Regional differences in the amount of injury, effect on yield and sugar content were observed. In Idaho and Nebraska, sugar content was not significantly reduced by any herbicide/insecticide combination. Differences were observed in North Dakota. Treatments in North Dakota had more effect on yield than treatments in Idaho or Nebraska. The environmental conditions and soil properties in these areas apparently influenced the amount of injury. Since climatic and soil properties differ among these areas, research needs to continue to define combinations and practices that work best for each area.

Table 6. Sugarbeet population, crop injury, root yield, and sucrose at Scottsbluff, Nebraska 1993.

Herbicide		Insecticide		Application	Sugarbeet						
					Population		Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method	5/25	6/9	5/27	6/8	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		----%----		tons/ha	%	kg/ha
None		None			75	77	0	1	67	14.6	8883
Desm & phen[‡]	0.37	None			76	83	9	13	70	15.5	9911
Triflusulfuron	0.018	None			98	101	3	3	87	15.3	12178
Desm & phen + triflusulfuron	0.37 + 0.018	None			87	87	10	8	73	15.4	10347
None		terbufos 15G	2.0	PPI	77	84	3	3	70	15.3	9846
Desm & phen	0.37	terbufos 15G	2.0	PPI	87	90	8	8	79	15.7	11294

[†]Surfactant was added to triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 6. (Continued)

Herbicide		Insecticide		Application	Sugarbeet						
					Population		Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method	5/25	6/9	5/27	6/8	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		----%----		tons/ha	%	kg/ha
Triflusulfuron	0.018	terbufos 15G	2.0	PPI	91	92	1	3	86	16.1	12687
Desm & phen + triflusulfuron	0.37 + 0.018	terbufos 15G	2.0	PPI	84	87	12	11	73	15.2	10196
None		terbufos 15G	4.0	PPI	83	82	1	1	73	15.1	9995
Desm & phen	0.37	terbufos 15G	4.0	PPI	75	82	15	18	76	14.7	10175
Triflusulfuron	0.018	terbufos 15G	4.0	PPI	97	95	3	3	88	15.3	12266
Desm & phen + triflusulfuron	0.37 + 0.018	terbufos 15G	4.0	PPI	81	84	10	9	70	15.0	9727

[†]Surfactant was added to triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 6. (Continued)

Herbicide		Insecticide		Application	Sugarbeet						
					Population		Injury		Root	Sucrose	Extractable
Treatment†	Rate	Treatment	Rate	Method	5/25	6/9	5/27	6/8	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		----%----		tons/ha	%	kg/ha
None		chlorpyrifos 15G	2.25	PPI	86	82	1	4	76	14.7	10108
Desm & phen	0.37	chlorpyrifos 15G	2.25	PPI	80	86	11	12	77	14.6	10220
Triflusulfuron	0.018	chlorpyrifos 15G	2.25	PPI	85	93	3	5	83	15.8	12009
Desm & phen + triflusulfuron	0.37 + 0.018	chlorpyrifos 15G	2.25	PPI	76	79	13	12	72	15.6	10221
None		chlorpyrifos 15G	4.5	PPI	77	81	1	3	73	15.4	10222
Desm & phen	0.37	chlorpyrifos 15G	4.5	PPI	81	85	13	16	72	16.0	10394
Triflusulfuron	0.018	chlorpyrifos 15G	4.5	PPI	78	78	10	15	74	16.2	11113

†Surfactant was added to triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.

‡Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 6. (Continued)

Herbicide		Insecticide		Application	Sugarbeet						
					Population		Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method	5/25	6/9	5/27	6/8	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		----%----		tons/ha	%	kg/ha
Desm & phen + triflusulfuron	0.37 + 0.018	chlorpyrifos 15G	4.5	PPI	89	92	12	11	74	15.1	10172
None		chlorpyrifos 4E	1.08	POST	83	81	1	1	71	15.5	9959
Desm & phen	0.37	chlorpyrifos 4E	1.08	POST	74	87	11	16	71	15.7	10055
Triflusulfuron	0.018	chlorpyrifos 4E	1.08	POST	93	94	7	8	81	15.7	11556
Desm & phen + triflusulfuron	0.37 + 0.018	chlorpyrifos 4E	1.08	POST	79	82	11	12	77	15.1	10528
None		chlorpyrifos 4E	2.25	POST	77	81	6	4	70	14.7	9382

[†]Surfactant was added to triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.

[‡]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 6. (Continued)

Herbicide		Insecticide		Application	Sugarbeet						
					Population		Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method	5/25	6/9	5/27	6/8	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		----%----		tons/ha	%	kg/ha
Desm & phen	0.37	chlorpyrifos 4E	2.25	POST	74	80	16	19	69	15.4	9689
Triflusulfuron	0.018	chlorpyrifos 4E	2.25	POST	92	93	7	10	76	16.1	11140
Desm & phen + triflusulfuron	0.37 + 0.018	chlorpyrifos 4E	2.25	POST	74	80	19	18	68	15.5	9687
None		aldicarb 15G	2.25	PPI	86	83	0	0	74	15.2	10148
Desm & phen	0.37	aldicarb 15G	2.25	PPI	79	85	8	12	71	15.3	9878
Triflusulfuron	0.018	aldicarb 15G	2.25	PPI	88	92	1	3	77	16.2	11512

[†]Surfactant was added to triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 6. (Continued)

Herbicide		Insecticide		Application	Sugarbeet						
					Population		Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method	5/25	6/9	5/27	6/8	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		----%----		tons/ha	%	kg/ha
Desm & phen + triflusulfuron	0.37 + 0.018	aldicarb 15G	2.25	PPI	87	88	8	7	73	15.4	10249
None		aldicarb 15G	4.5	PPI	83	78	3	3	67	15.0	9158
Desm & phen	0.37	aldicarb 15G	4.5	PPI	78	85	8	10	78	15.4	10902
Triflusulfuron	0.018	aldicarb 15G	4.5	PPI	97	91	3	3	76	15.9	11142
Desm & phen + triflusulfuron	0.37 + 0.018	aldicarb 15G	4.5	PPI	78	84	11	8	74	15.4	10417
LSD (0.05)					NS	NS	NS	6	NS	NS	NS

[†]Surfactant was added to triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 7. Sugarbeet stand, crop injury, and root yield at Scottsbluff, Nebraska 1994.

Herbicide		Insecticide		Application	Sugarbeet						
					Population		Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method	5/31	6/7	6/1	6/7	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		----%----		tons/ha	%	kg/ha
None		None			84	79	1	5	65	17.4	10265
Desm & phen[‡]	0.37	None			86	84	9	8	59	17.2	9185
Triflusulfuron	0.018	None			87	79	4	8	63	16.8	9620
Desm & phen + triflusulfuron	0.37 + 0.018	None			76	75	14	15	60	17.4	9380
None		terbufos 15G	2.0	PPI	103	103	5	9	58	17.7	9290
Desm & phen	0.37	terbufos 15G	2.0	PPI	109	105	1	5	61	17.1	9500

[†]Surfactant was added to triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 7. (Continued)

Herbicide		Insecticide		Application	Sugarbeet						
					Population		Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method	5/31	6/7	6/1	6/7	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		----%----		tons/ha	%	kg/ha
Triflusulfuron	0.018	terbufos 15G	2.0	PPI	105	103	4	6	69	17.0	10650
Desm & phen + triflusulfuron	0.37 + 0.018	terbufos 15G	2.0	PPI	108	108	9	12	57	17.7	9120
None		terbufos 15G	4.0	PPI	100	104	5	8	55	17.2	8610
Desm & phen	0.37	terbufos 15G	4.0	PPI	100	103	4	6	57	17.1	8890
Triflusulfuron	0.018	terbufos 15G	4.0	PPI	99	102	9	14	65	17.1	10075
Desm & phen + triflusulfuron	0.37 + 0.018	terbufos 15G	4.0	PPI	102	101	13	14	61	17.1	9355

[†]Surfactant was added to triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 7. (Continued)

Herbicide		Insecticide		Application	Sugarbeet						
					Population		Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method	5/31	6/7	6/1	6/7	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		----%----		tons/ha	%	kg/ha
None		chlorpyrifos 15G	2.25	PPI	96	98	7	9	62	17.3	9715
Desm & phen	0.37	chlorpyrifos 15G	2.25	PPI	99	101	8	13	59	17.1	9145
Triflusulfuron	0.018	chlorpyrifos 15G	2.25	PPI	89	89	9	16	66	16.8	10045
Desm & phen + triflusulfuron	0.37 + 0.018	chlorpyrifos 15G	2.25	PPI	89	89	16	18	61	17.7	9770
None		chlorpyrifos 15G	4.5	PPI	96	90	13	23	55	17.4	8660
Desm & phen	0.37	chlorpyrifos 15G	4.5	PPI	93	91	10	13	59	16.7	8985

[†]Surfactant was added to triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 7. (Continued)

Herbicide		Insecticide		Application	Sugarbeet						
					Population		Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method	5/31	6/7	6/1	6/7	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		----%----		tons/ha	%	kg/ha
Triflusulfuron	0.018	chlorpyrifos 15G	4.5	PPI	98	91	15	23	62	16.7	9370
Desm & phen + triflusulfuron	0.37 + 0.018	chlorpyrifos 15G	4.5	PPI	96	87	13	18	65	16.7	9775
None		chlorpyrifos 4E	1.08	POST	90	94	7	12	60	17.3	9390
Desm & phen	0.37	chlorpyrifos 4E	1.08	POST	95	97	5	9	60	16.9	9250
Triflusulfuron	0.018	chlorpyrifos 4E	1.08	POST	83	84	12	19	64	17.4	10200
Desm & phen + triflusulfuron	0.37 + 0.018	chlorpyrifos 4E	1.08	POST	93	92	10	11	64	17.3	10010

[†]Surfactant was added to triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

Table 7. (Continued)

Herbicide		Insecticide		Application	Sugarbeet						
					Population		Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method	5/31	6/7	6/1	6/7	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		----%----		tons/ha	%	kg/ha
None		chlorpyrifos 4E	2.25	POST	85	89	11	16	59	17.8	9610
Desm & phen	0.37	chlorpyrifos 4E	2.25	POST	90	89	7	11	55	16.9	8515
Triflusulfuron	0.018	chlorpyrifos 4E	2.25	POST	96	86	16	20	60	17.2	9475
Desm & phen + triflusulfuron	0.37 + 0.018	chlorpyrifos 4E	2.25	POST	80	83	13	18	56	17.2	8730
None		aldicarb 15G	2.25	PPI	83	84	4	9	63	16.8	9595
Desm & phen	0.37	aldicarb 15G	2.25	PPI	98	96	4	5	63	16.6	9545

[†]Surfactant was added to triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]Desm & phen = preformulated mixture of desmedipham and phenmedipham

Table 7. (Continued)

Herbicide		Insecticide		Application	Sugarbeet						
					Population		Injury		Root	Sucrose	Extractable
Treatment[†]	Rate	Treatment	Rate	Method	5/31	6/7	6/1	6/7	Yield	Content	Sucrose
	kg/ha		kg/ha		plants/15 m		----%----		tons/ha	%	kg/ha
Triflusulfuron	0.018	aldicarb 15G	2.25	PPI	98	94	6	11	63	16.8	9630
Desm & phen + triflusulfuron	0.37 + 0.018	aldicarb 15G	2.25	PPI	91	89	6	6	72	16.7	10920
None		aldicarb 15G	4.5	PPI	95	91	3	4	66	17.1	10220
Desm & phen	0.37	aldicarb 15G	4.5	PPI	100	98	4	9	67	16.6	10110
Triflusulfuron	0.018	aldicarb 15G	4.5	PPI	95	94	3	7	66	16.6	9915
Desm & phen + triflusulfuron	0.37 + 0.018	aldicarb 15G	4.5	PPI	84	85	8	9	59	17.0	9070
LSD (0.05)					18	19	7	10	12	NS	2070

[†]Surfactant was added to triflusulfuron treatments at 0.25% v/v. All herbicide treatments were applied sequentially at the cotyledon and two-leaf growth stage.
[‡]Desm & phen = preformulated mixture of desmedipham and phenmedipham.

LITERATURE CITED

Abivardi, C. and J. Altman. 1978. Effect of cycloate and aldicarb alone and in combination on growth of three sugarbeet species (*Beta spp.*). Weed Sci. 26:161-162.

Arle, H.F. 1968. Trifluralin-systemic insecticide interactions on seedling cotton. Weed Sci. 16:430-432.

Biediger, D.L., F.A. Baumann, D.N. Weaver, J.M. Chandler, and M.G. Merkle. 1992. Interactions between primisulfuron and selected soil-applied insecticides in corn (*Zea mays*). Weed Technology 6:807-812.

Chapman, R.A. and C.R. Harris. 1980. Insecticidal activity and persistence of terbufos, terbufos sulfoxide and terbufos sulfone in soil. Journal of Economic Entomology 73:536-543.

Cole, D.F. and A.G. Dexter. 1985. Effect of multiple pesticide treatments on sugarbeet yield and quality. J. Am. Soc. Sugar Beet Technol. 23:109-115.

Hacskaylo, J., J.K. Walker, and E.G. Pires. 1964. Response of cotton seedlings to combinations of preemergence herbicides and systemic insecticides. Weeds 12:288-291.

Hassaway, G.S. and K.C. Hamilton. 1971. Effects of trifluralin and organophosphorus compounds on cotton seedlings. Weed Sci. 19:166-169.

Hayes, R.M., K.V. Yeargan, W.W. Witt and H.G. Raney. 1979. Interaction of selected insecticide-herbicide combinations on soybeans (*Glycine max*). Weed Sci. 27:51-53.

Jordan, D.L., R.E. Frans, and M.R. McClelland. 1993. DPX-PE350 does not interact with early-season insecticides in cotton (*Gossypium hirsutum*). Weed Technology 7:92-93.

Kapusta, G. and R.F. Krausz. 1992. Interaction of terbufos and nicosulfuron on corn (*Zea mays).* Weed Technology 6:999-1003.

Lee, G.A., H.P. Alley, and D.J. Krionderis. 1969. Effect of pyrazon and cycloate in combination with phorate on phytotoxicity to sugarbeet seedlings. Res. Prog. Rep. West. Soc. Weed. Sci. 92-93.

Morton, C.A., R.G. Harvey, J.J. Kells, W.E. Lueschen, and V. A. Fritz. 1991. Effect of DPX-V9360 and terbufos on field and sweet corn (*Zea mays*) under three environments. Weed Technology 5:130-136.

Parks, J.P., B. Truelove, and G.A. Buchanan. 1972. Interaction of prometryn and phorate on bean. Weed Sci. 20:89-92.

Waldrop, D.D. and P.A. Banks. 1983. Interactions of herbicides with insecticides in soybeans (*Glycine max*). Weed Sci. 31:730-734.

Wedderburn, R.N., L.E. Jenkins and E.E. Schweizer. 1973. Effects of combinations of liquid and granular formulations of disulfoton and cycloate on sugarbeets. Environmental Entomology 2:915-917.

Wilson, R.G. and G.L. Hein. 1991. Effect of herbicides and insecticides applied to sugarbeets at planting. J. Sugar Beet Res. 28:115-128.