CONTROL OF KOCHIA RESISTANT TO ALS-INHIBITING HERBICIDES IN SUGARBEET

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ABSTRACT

Field research was conducted in the Red River Valley of eastern North Dakota and western Minnesota from 1999 through 2002. Kochia control increased as the number of POST applications of herbicide combinations at 25 to 33% of a conventional rate plus methylated seed oil adjuvant (micro-rate) increased from two to four. Glyphosate at 0.8 kg/ha applied twice on glyphosate-resistant sugarbeet gave total kochia control and no sugarbeet injury. Conventional rates of POST herbicide combinations applied three times without adjuvant gave better kochia control and similar redroot pigweed control compared to the same herbicides at the micro-rate plus adjuvant applied four times. Desmedipham in combination with triflusulfuron, clopyralid and clethodim gave less kochia control and greater redroot pigweed control than desmedipham & phenmedipham & ehtofumesate in combination with the same herbicides while desmedipham & phenmedipham combinations were intermediate. PRE ethofumesate followed by POST herbicide combinations gave better control of kochia and redroot pigweed than POST herbicides alone. The micro-rate plus dimethenamid-P in the third of four micro-rate applications gave more sugarbeet injury and greater kochia and redroot pigweed control compared to the micro-rate alone. PRE ethofumesate followed by the micro-rate gave less sugarbeet injury, better kochia control and similar redroot pigweed control compared to dimethenamid-P plus the micro-rate. The micro-rate applied four times plus ethofumesate at 0.14 kg/ha in the first two applications gave better kochia control than the micro-rate alone. Fluroxypyr plus the micro-rate gave better kochia control than the micro-rate alone but fluroxypyr caused unacceptable sugarbeet injury and yield loss.

INTRODUCTION

Kochia [*Kochia scoparia* (L.) Schrad.] seed was collected from individual kochia plants in sugarbeet fields in western Minnesota, North Dakota, and eastern Montana during the fall of 1999 by agriculturists from American Crystal Sugar Company, Minn-Dak Farmers Cooperative and the Holly Sugar Corporation factory at Sidney, MT. Seed from each plant was grown in pots and treated with triflusulfuron at 17.5 g/ha in a greenhouse at North Dakota State University. One or more kochia plants resistant to triflusulfuron were found in 98% of the 461 seed samples that produced viable seed. Also, 74% of the 3725 total plants grown in the greenhouse were resistant to triflusulfuron. This indicates that

kochia resistant to ALS-inhibiting herbicides is very common in sugarbeet producing regions of western Minnesota, North Dakota and eastern Montana. Postemergence (POST) herbicide treatments including desmedipham (Betanex) or desmedipham & phenmedipham (Betamix) or desmedipham & phenmedipham & ethofumesate (Progress) plus triflusulfuron (UpBeet) plus clopyralid (Stinger) were applied an average of 2.95 times per sugarbeet field and soil-applied herbicides were used on 4% of the sugarbeet fields in 2002 according the an annual survey of sugarbeet growers in eastern North Dakota and Minnesota. In the 2002 survey, 26% of the respondents identified kochia and 44% identified pigweed species as the "worst weed problem" in sugarbeet. Kochia and pigweed species were named as "worst weed" more often than the other weeds in the last five years of the survey. The objective of this research was to determine sugarbeet injury and control of kochia and redroot pigweed from conventional and micro-rates of herbicide combinations.

MATERIALS AND METHODS

Field research was conducted in the Red River Valley of eastern North Dakota and western Minnesota from 1999 through 2002. Herbicides were applied in 158 L/ha of water at 280 kPa through 8002 flat-fan nozzles to the center four rows of six-row plots with four replicates. Plots were 9 to 12 m long and row spacing was 56 cm. The first of three or four sequential POST herbicide treatments was applied when sugarbeet was in the cotyledon to early two-leaf stage and subsequent sequential treatments were at 7-day intervals except when weather caused brief delays. Preemergence (PRE) ethofumesate was applied to the soil surface immediately after seeding. Weed control and sugarbeet injury were evaluated visually.

RESULTS AND DISCUSSION

Kochia control increased as the number of applications of desmedipham + triflusulfuron + clopyralid + clethodim + methylated seed oil adjuvant at the micro-rate increased from two to four (Table 1). Glyphosate at 0.8 kg/ha applied twice gave total control of kochia and no injury to glyphosate-resistant sugarbeet.

A micro-rate of six herbicides plus oil adjuvant applied four times POST (Table 2, Treatment 1) gave kochia and redroot pigweed (*Amaranthus retroflexus* L.) control similar to a conventional rate of the same six herbicides without oil adjuvant applied three times (Treatment 3). Using desmedipham & phenmedipham & ethofumesate at increasing rates of 0.28, 0.38 and 0.55 kg/ha in the three applications (Treatment 4) gave better control of kochia than the micro-rate (Treatment 1) or 0.28 kg/ha in all three applications (Treatment 3). The micro-rate applied four times plus ethofumesate at 0.14 kg/ha in the first two applications (Treatment 2) gave better control of kochia than the micro-rate alone (Treatment 1). Ethofumesate at 0.14 kg/ha in the first two applications of a conventional rate (Treatment 6) gave kochia and redroot pigweed control similar to the same herbicides without the extra ethofumesate (Treatment 5). Doubling the rate of triflusulfuron in the conventional rate from 0.009 kg/ha

(Treatment 4) to 0.018 kg/ha (Treatment 5) did not significantly improve kochia or redroot pigweed control. PRE ethofumesate at 3.4 kg/ha followed by POST herbicides (Treatments 7 and 8) gave better control of kochia and redroot pigweed than the POST herbicides alone (Treatments 1 and 4). PRE ethofumesate followed by a conventional rate of POST herbicides (Treatment 8) gave 87% control of kochia, the best control of any treatment in the experiment. Sugarbeet injury only varied from 9 to 15% among treatments and yield of hand-weeded sugarbeet at one location was similar regardless of treatment.

Desmedipham, desmedipham & phenmedipham, and desmedipham & phenmedipham & ethofumesate were substituted for one another in micro-rate and conventional rate treatments (Table 3). Desmedipham in combination with triflusulfuron, clopyralid and clethodim gave (less) control of kochia and greater (control of redroot pigweed) than desmedipham & phenmedipham & ethofumesate in combination with triflusulfuron, clopyralid and clethodim while desmedipham & phenmedipham combinations were intermediate (Treatments 1, 2 and 3 and Treatments 5, 6, and 7). The micro-rate with desmedipham & phenmedipham & ethofumesate applied four times plus extra ethofumesate at 0.14 kg/ha in the first two applications (Treatment 4) gave greater control of kochia than the micro-rate without extra ethofumesate (Treatment 3). Triflusulfuron at 0.018 kg/ha applied three times in combination with other herbicides (Treatment 8) gave better control of redroot pigweed than treatments with triflusulfuron at 0.009 kg/ha applied three times. This differs from the results observed in 2001 (Table 2) where increasing triflusulfuron rate did not improve redroot pigweed control. The environment in 2002 favored a long period of redroot pigweed emergence while the environment in 2001 did not. The high rate of triflusulfuron in 2002 may have had enough soil residual to have reduced emergence of late germinating redroot pigweed.

The micro-rates of POST treatments applied four times gave or tended to give less sugarbeet injury, less kochia control and similar redroot pigweed control compared to the same herbicides at the conventional rates applied three times (Table 3). PRE ethofumesate at 3.4 kg/ha followed by the micro-rate (Treatment 9) gave better control of kochia than PRE ethofumesate at 2.2 kg/ha followed by the micro-rate (Treatment 10). PRE ethofumesate at 3.4 kg/ha followed by the micro-rate (Treatment 9) gave control of kochia and redroot pigweed similar to PRE ethofumesate at 3.4 kg/ha followed by the conventional rate (Treatment 11). This differs from the results in 2001 (Table 2) where the conventional rate over PRE ethofumesate gave better kochia control than the micro-rate over PRE ethofumesate. The kochia population were greater in 2001 than in 2002 so the higher herbicide rates perhaps were more beneficial in 2001.

Dimethenamid-P was added to the third of four applications of the micro-rate as a lay-by treatment (Table 3, Treatment 12). The micro-rate plus dimethenamid-P gave more sugarbeet injury and greater control of kochia and redroot pigweed compared to the micro-rate alone (Treatment 3). PRE ethofumesate followed by the micro-rate (Treatment 9) gave less sugarbeet injury, better control of kochia and similar control of redroot pigweed compared to the micro-rate plus dimethenamid-P (Treatment 12). Sugarbeet at one location was resistant to glyphosate and was broadcast treated with glyphosate and hand weeded to control weeds. Yield of these sugarbeet was similar regardless of herbicide

treatment (Table 3).

Fluroxypyr was added to the micro-rate of desmedipham & phenmedipham + triflusulfuron + methylated seed oil adjuvant in the second, third or fourth of four applications (Tables 4 and 5). The time of application interactions were not significant so the data were combined over application times. Fluroxypyr is known to provide good to excellent control of ALS-resistant kochia at a normal labeled rate of 0.14 kg/ha.

The micro-rate plus fluroxypyr gave greater control of kochia than the micro-rate alone even at the lowest tested rate of 0.017 kg/ha or 12% of the normal labeled fluroxypyr rate (Table 4). Kochia control was greater in 2000 than in 2001, perhaps due to higher kochia populations in 2001.

The year interactions for sugarbeet injury and yield were not significant so injury and yield were combined over years (Table 5). All treatments that included fluroxypyr caused more sugarbeet injury than the micro-rate alone. Sugarbeet yield was significantly reduced by all but the lowest rate of fluroxypyr and even the lowest rate tended to reduce yield. The results of research with fluroxypyr indicate that sugarbeet does not have sufficient tolerance to fluroxypyr for commercial use for kochia control in sugarbeet.

Table 1. Kochia control and sugarbeet injury at Fargo, 1999.

Treatment[1]	Application dates	Sugb[1] inj	Kochia cntl
		%	%
Desm + tfsu + clpy + clet + MSO 0.09 + 0.004 + 0.03 + 0.03 kg/ha + 1.5% v/v	6/1, 6/7	10	59
	6/1, 6/7, 6/14	11	90
	6/1, 6/7, 6/14, 6/24	18	97
Glyphosate 0.8 kg/ha	6/7, 6/24	0	100
LSD (0.05)		15	9

[1]*Desm = desmedipham (Betanex), tfsu = triflusulfuron (UpBeet), clpy = clopyralid (Stinger), clet = clethodim (Select), MSO = methylated seed oil adjuvant (MethOil), glyphosate (Roundup), sugb = sugarbeet.*

Table 2. Weed control and sugarbeet injury with the micro-rate and conventional rates of sugarbeet herbicides at three locations, 2001.

Treatment[1]	3 loc[1] Sugb inj	3 loc Kochia cntl	1 loc[1] Rrpw cntl	1 loc Extrac.[2] sucrose
	%	%	%	kg/ha
1. Desm & phen & etho + tfsu + clpy + clet + MSO (T1-T4) 0.09 + 0.004 + 0.03 + 0.03 kg/ha + 1.5% v/v	13	50	90	7960
2. Desm & phen & etho + tfsu + clpy + clet + MSO (T1-T4) + etho (T1, T2) 0.09 + 0.004 + 0.03 + 0.03 kg/ha + 1.5% + 0.14 kg/ha	10	68	91	7420
3. Desm & phen & etho + tfsu + clpy + clet (T1-T3) 0.28 + 0.009 + 0.05 + 0.05 kg/ha	9	55	88	7470
4. Desm & phen & etho + tfsu + clet (T1-T3) 0.28 (T1)/0.38 (T2)/0.55 (T3) + 0.009 + 0.05 kg/ha (T1-T3)	14	72	94	6930
5. Desm & phen & etho + tfsu + clet (T1-T3) 0.28 (T1)/0.38 (T2)/0.55 (T3) + 0.018 + 0.05 kg/ha (T1-T3)	15	75	97	7660
6. Desm & phen & etho + tfsu + clet (T1-T3) + etho (T1-T2) 0.28 (T1)/0.38 (T2)/0.55(T3) + 0.018 + 0.05 kg/ha + 0.14 kg/ha	15	80	91	8050
7. Ethofumesate (PRE) 3.4 kg/ha followed by Desm & phen & etho + tfsu + clpy + MSO (T1-T4) 0.09 + 0.004 + 0.03 + 0.03 kg/ha + 1.5%	11	79	99	6830
8. Ethofumesate (PRE) 3.4 kg/ha followed by Desm & phen & etho + tfsu + clet (T1-T3) 0.28 (T1)/0.38 (T2)/0.55 (T3) + 0.009 + 0.05 kg/ha (T1-T3)	13	87	99	7660
LSD (0.05)	5	6	7	NS

[1]Desm & phen & etho = desmedipham & phenmedipham & ethofumesate (Progress), tfsu = triflusulfuron (UpBeet), clpy = clopyralid (Stinger), clet = clethodim (Select), etho = ethofumesate (Nortron), MSO = methylated seed oil adjuvant (Scoil), Sugb = sugarbeet, Rrpw = redroot pigweed, 3 loc = averaged over three locations, T1 = first postemergence treatment timing.

[2]Harvested plots were maintained free of weeds throughout the growing season to evaluate herbicide effect on sugarbeet yield without competition from weeds.

Table 3. Weed control and sugarbeet injury with the micro-rate and conventional rates of sugarbeet herbicides at seven locations , 2002.

Treatment[1]	6 loc[1] Sugb inj	1 loc Kochia cntl	4 loc Rrpw[1] cntl	1 loc Extrac.[2] sucrose
	%	%	%	kg/ha
1. Desm + tfsu + clpy + clet + MSO (T1-T4) 0.09 + 0.004 + 0.03 + 0.03 kg/ha + 1.5% v/v	8	53	82	5100
2. Desm & phen + tfsu + clpy + clet + MSO (T1-T4) 0.09 + 0.004 + 0.03 + 0.03 kg/ha + 1.5%	10	58	79	5040
3. Desm & phen & etho + tfsu + clpy + clet + MSO (T1-T4) 0.09 + 0.004 + 0.03 + 0.03 kg/ha + 1.5%	7	60	76	5290
4. Desm & phen & etho + tfsu + clpy + clet + MSO (T1-T4) + etho (T1, T2) 0.09 + 0.004 + 0.03 + 0.03 kg/ha + 1.5% + 0.14 kg/ha	7	76	78	5910
5. Desm + tfsu + clpy + clet (T1-T3) 0.28 (T1)/0.38 (T2)/0.55 (T3) + 0.009 + 0.05 + 0.05 kg/ha	11	72	83	5310
6. Desm & phen + tfsu + clpy + clet (T1-T3) 0.28 (T1)/0.38 (T2)/0.55 (T3) + 0.009 + 0.05 + 0.05 kg/ha	11	76	83	5390
7. Desm & phen & etho + tfsu + clpy + clet (T1-T3) 0.28 (T1)/0.38 (T2)/0.55 (T3) + 0.009 + 0.05 + 0.05 kg/ha	10	86	76	5390
8. Desm & phen & etho + tfsu (T1) 0.16 + 0.018 Desm & phen & etho + tfsu + clpy (T2, T3) 0.38 (T2)/0.47 (T3) + 0.018 + 0.12 kg/ha	13	94	90	5420
9. Ethofumesate (PRE) 3.4 kg/ha followed by Desm & phen & etho + tfsu + clpy + clet + MSO (T1-T4) 0.09 + 0.004 + 0.03 + 0.03 kg/ha + 1.5%	8	91	86	6060
10. Ethofumesate (PRE) 2.2 kg/ha followed by Desm & phen & etho + tfsu + clpy + clet + MSO (T1-T4) 0.09 + 0.004 + 0.03 + 0.03 kg/ha + 1.5%	7	72	82	5620
11. Ethofumesate (PRE) 3.4 kg/ha followed by Desm & phen & etho + tfsu + clpy + clet (T1-T3) 0.28 (T1)/0.38 (T2)/0.55 (T3)/ + 0.009 + 0.05 + 0.05 kg/ha	11	87	90	5260
12. Desm & phen & etho + tfsu + clpy + clet + MSO (T1-T4) 0.09 + 0.004 + 0.03 + 0.03 kg/ha + 1.5% with dimethenamid-P at 1.1 kg/ha (T3)	12	74	86	5190
LSD (0.05)	3	11	5	NS

[1]Desm = desmedipham (Betanex), desm & phen = desmedipham & phenmedipham (Betamix), desm & phem & etho = desmedipham & phenmedipham & ethofumesate (Progress), tfsu = triflusulfuron (UpBeet), clpy = clopyralid (Stinger), clet = clethodim (Select), MSO = methylated seed oil adjuvant (MSO), etho = ethofumesate (Nortron),

Sugb = sugarbeet, Rrpw = redroot pigweed, 6 loc = averaged over six locations, T1 = first postemergence treatment timing.

[2]*Harvested plots were maintained free of weeds throughout the growing season to evaluate herbicide effect on sugarbeet yield without competition from weeds.*

Table 4. Influence of fluroxypyr plus the micro-rate of sugarbeet herbicides on kochia control averaged over three locations in 2000 and 2001.

Treatment	Fluroxypyr rate	Kochia control 2000	Kochia control 2001
	kg/ha	%	%
Desm & phen + tfsu + MSO (T1-T4) 0.09 + 0.004 kg/ha + 1.5% v/v	0	82	42
Fluroxypyr added once at T2, T3 or T4	0.017	92	68
	0.034	97	75
	0.067	98	81
	0.14	98	87
LSD (0.05)		2	4

[1]*Desm & phen = desmedipham & phenmedipham (Betamix), tfsu = triflusulfuron (UpBeet), MSO = methylated seed oil adjuvant (Scoil), sugb = sugarbeet, fluroxypyr (Starane), T2 = second application of micro-rate.*

Table 5. Influence of fluroxypyr plus the micro-rate of sugarbeet herbicides on sugarbeet injury and yield averaged over 2000 and 2001.

		St. Thomas 2000, 2001	
Treatment[1]	Fluroxypyr rate	Sugb inj	Extrac. sucrose
	kg/ha	%	kg/ha
Desm & phen + tfsu + MSO (T1-T4) 0.09 + 0.004 kg/ha + 1.5% v/v	0	6	5720
Fluroxypy added once	0.017	27	5550
at T2, T3 or T4	0.034	36	4870
	0.067	56	4790
	0.14	68	3390
LSD (0.05)		6	390

[1]Desm & phen = desmedipham & phenmedipham (Betamix), tfsu = triflusulfuron (UpBeet), MSO = methylated seed oil adjuvant (Scoil), sugb = sugarbeet, fluroxypyr (Starane), T2 = second application of micro-rate.