ADJUVANTS IMPROVE CONTROL OF WARM ZONE GRASSES WITH SULFONYLUREA HERBICIDES IN MAIZE

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Summary. Several pot experiments evaluated the effects of growth stage and of various adjuvants on the efficacy of rimsulfuron, nicosulfuron and primisulfuron on warm zone grass weeds. Two field trials in maize crops also evaluated the best adjuvants with rimsulfuron and primisulfuron under temperate conditions in New Zealand. In pot experiments rimsulfuron and nicosulfuron had a similar level of activity and were more active on grass wees than was primisulfuron. Of the grass weeds smooth witchgrass, *Panicum dichotomiflorum*, was more readily controlled than whorled pigeon grass, *Setaria verticillata* and summer grass, *Digitaria sanguinalis*. The most successful application time was when the grasses had two to four leaves as the level of control decreased once they began to tiller. The adjuvants Pulse, Ethokem and Citowett were more effective than crop oil and X-45. These results were reflected in the field trials where the use of an adjuvant was essential to maximise phytotoxicity of all three herbicides. Rimsulfuron gave effective control of a range of grass weeds while primisulfuron was more effective on broadleaf weeds.

INTRODUCTION

The sulfonylurea herbicides are being developed for a variety of uses. Various members of this group are registered for use in cereals, rice, soy beans, oilseed rape as well as for total vegetation control. Others are being developed for use in several other crops and pastures, as well as for aquatic weed control (1,2,3,6). The broad spectrum and reliability of weed control, the low dose rate and the favourable toxicological profiles of these compounds have contributed to the rapid rise in the use of this group of herbicides.

Over the last few years several sulfonylurea compounds have been evaluated for weed control in maize. Nicosulfuron, rimsulfuron and primisulfuron have all shown promise for control of certain troublesome perennial grasses at rates similar to those required for annual grass weeds, as well as providing good control or suppression of many broad-leaved weeds (5, 7, 11). Our early developmental work with these three herbicides in the field indicated that non of them provided adequate control of summer grass, one of the major annual grass weeds of the maize growing regions in New Zealand (12). Oil and surfactant adjuvants have been reported to enhance the activity of many post-emergence herbicides including sulfonylureas, and maintain their effectiveness across varied environments (4,8,9,10). The present study, comprising both pot and field experiments, investigated whether certain adjuvants and additives can enhance the phytotoxicity of the three sulfonylurea herbicides on the major warm zone grass weeds of maize fields in New Zealand.

METHODS

Pot experiments. Four experiments were conducted on grass weeds grown outdoors in pots over a two year period. The grasses were established by potting out soils known to contain a natural seed bank of the desired species and then removing unwanted plants by hand. In the first two experiments, initiated 8 January and 1 February 1990, three species were grown, viz. summer grass, smooth witchgrass and whorled pigeon grass, while the second two experiments, laid

down on 21 December 1990 and 3 January 1991, included only summer grass and smooth witchgrass. In all experiments the herbicides were applied at three rates to each of three growth stages, 2-leaf, 4-leaf and 6-leaf, with a variety of adjuvants. The herbicides used were rimsulfuron, nicosulfuron and primisulfuron. Rimsulfuron was applied at 10, 15 and 20 g/ha at the 2 and 4-leaf stages and at 15, 20 and 30 g/ha at the 6-leaf stage while nicosulfuron were used at 30, 45 and 60 g/ha at the 2 and 4-leaf stages and at 45, 60 and 80 g/ha at the 6-leaf stage. The adjuvants used were an emulsifiable vegetable oil (Codacide oil), an organo-silicone co-polymer surfactant silwet-M (Pulse), a white emulsifiable crop oil (BP crop oil), a cationic wetting agent polyethanoxyl alkyl amine (Ethokem) and the non-ionic surfactants, alkylarylpolyglycol ether (Citowett) and alkylarylpolyether alcohol (Triton X-45) (see Table 1 for rates). In all experiments the herbicide/adjuvant combinations were premixed according to label instructions and applied with a moving belt CO_2 powered sprayer, fitted with an 8003 even spray nozzle, delivering 300 L/ha at 200 kPa. For the duration of each experiment pots were watered every 2-3 days as required to maintain the soil between 70 and 90% of field capacity. Day temperatures were between 20 and 25°C, with night temperatures sometimes dropping to 10°C. Herbicide response was evaluated by regular visual damage assessments and by counting the surviving plants 4-5 weeks after spraying.

Table 1. Effect of adjuvants on the activity of three sulfonylurea herbicides on summer grass (DIGSA) and smooth witchgrass (PANDI) at the 2-leaf stage

Adjuvant	Rate	% Control					
		Nicosulfuron[a]		Rimsulfuron		Primisulfuron	
		DIGSA	PANDI	DIGSA	PANDI	DIGSA	PANDI
-	-	52	65	50	60	48	75
Pulse	0.2% v/v	63	92	85	100	60	95
Citowett	0.2% v/v	50	85	82	100	53	97
Triton X-45	0.2% v/v	48	90	63	95	52	95
Ethokem	1 L/ha	100	100	95	100	55	100
crop oil	2 L/ha	48	95	80	95	57	100
Codacide oil	1 L/ha	50	97	95	98	57	95
l.s.d. (P=0.05)		12.8	8.5	9.2	6.3	12.8	4.6

[a] Nicosulfuron and primisulfuron applied at 30 g/ha, rimsulfuron at 10 g/ha.

Field experiments. Two field trials were conducted in maize, *Zea mays*, on a Horotiu sandy loam soil with 61% sand, 16% clay, 5.8% organic C and a pH of 5.6. The maize cv. Pioneer 3475 was planted on 22 October 1991 and 20 October 1992 with a Nodet Gougis precision seeder at 88,000 seeds/ha and 75 cm row spacing. For Trial 1 (Table 2), alachlor was applied 2 days after planting; all other treatments were applied 35 days after planting when maize plants had 4-5 leaves, grass weeds 1-6 leaves and broadleaf weeds 4-12 leaves. For the post-emergence treatments the weather was sunny and 19°C and 3 mm of rain fell within 24 hrs of application. For Trial 2 (Table 3), alachlor was applied 7 days after planting; all other treatments were applied 29 days after planting, when maize plants had 3-4 leaves, grass weeds 3-5 leaves and broadleaf weeds 4-6 leaves. Conditions for the post-emergence treatments were overcast and 17°C and 4.3 mm of rain fell within 24 hrs of treatment. Both trials were of a randomised block design with four replicates and individual plots of 10x3 m. All treatments were applied with a CO_2 powered precision sprayer in 200 L water/ha at 210 kPa. Visual

assessments for weed control and crop damage were made at regular intervals after treatment. Weed dry matter production was determined 6-8 weeks after planting by harvesting duplicate 0.5 m^2 quadrats from each plot and dissecting into grass and broadleaf weeds before drying. Grain yields for Trial 1 were determined by harvesting 25 cobs from each of the two central rows of each plot. The cobs were shelled, weighed and the moisture content of the grain measured. Grain yields are adjusted to 14% moisture levels.

Table 2. Effect of treatments on grass and broadleaf weeds in maize, Field Experiment 1

Adjuvant	Rate	Adjuvant	Weed assessment				Crop yield (t/ha)
			% Control		Dry matter (kg/ha)		
			Grass 18.12.91	Broadleaf 18.12.91	Grass 30.12.92	Broadleaf 30.1.92	5.5.92
rimsulfuron	5	-	27.5	32.5	206 b	1316 a	6.23
rimsulfuron	10	-	42.5	40.0	35 c	1505 a	7.56
rimsulfuron	5	crop oil 2 L/ha	67.5	47.5	272 b	1597 a	6.05
rimsulfuron	5	Ethokem 3 L/ha	42.5	63.8	76 bc	1186 a	8.13
rimsulfuron	5	Pulse 0.2%	40.0	63.8	118 b	1612 a	7.13
rimsulfuron	5	Citowett 0.2%	27.5	57.5	118 b	1507 a	6.89
primisulfuron	30	-	27.5	76.3	1058 a	219 b	7.72
primisulfuron	30	crop oil 2 L/ha	55.0	86.3	701 a	149 b	7.82
primisulfuron	30	Ethokem 3 L/ha	42.5	90.0	310 a	297 b	8.75
primisulfuron	30	Pulse 0.2%	17.5	83.8	578 a	21 b	8.49
primisulfuron	30	Citowett 0.2%	96.3	85.0	866 a	150 b	8.24
alachlor	3500	-		60.0	1 c	2451 a	7.70
l.s.d. (P=0.05)			20.0	17.1	-*	-*	2.43

* Analysis performed on log transformed data, numbers followed by different letters are significantly different at the 5% level using l.s.d. test.

Table 3. Effect of treatments on grass and broadleaf weeds in maize, Field Experiment 2

Adjuvant	Rate	Adjuvant	Weed assessment			
			% Control		Dry matter (kg/ha)	
			Grass 18.12.91	Broadleaf 18.12.91	Grass 30.12.92	Broadleaf 30.1.92
rimsulfuron	10	-	47.5	58.8	481 abc	752 ab
rimsulfuron	10	Ethokem 3 L/ha	81.3	61.3	102 d	326 bc
rimsulfuron	10	Pulse 0.2%	81.3	65.0	166 bcd	768 ab
rimsulfuron	10	Citowett 0.2%	77.5	75.0	307 bcd	328 bc
primisulfuron	30	-	48.8	58.8	501 ab	684 b
primisulfuron	30	Ethokem 3 L/ha	65.0	98.8	1191 a	110 c
primisulfuron	30	Pulse 0.2%	70.0	98.8	907 a	227 bc
primisulfuron	30	-	95.0	80.0	21 e	841 ab
alachlor	3500	-	0	0	106 cd	3378 a
untreated	-					
l.s.d. (P=0.05)			12.9	19.4	-*	-*

* Analysis performed on log transformed data, numbers followed by different letters are significantly different at the 5% level using l.s.d. test.

RESULTS AND DISCUSSION

Pot experiments. The initial experiments with pot grown grass weeds showed that the activity of all three sulfonylurea herbicides was enhanced by the use of certain adjuvants. The results presented in Table 1, from the third experiment, are typical of those obtained from all four experiments. Of the three grasses used in these experiments smooth witchgrass was most susceptible, with all three herbicides achieving good control at the 2-leaf stage when used with an adjuvant. However, at the 4 and 6-leaf stages, smooth witchgrass proved more difficult to control, with only Ethokem and Codacide oil providing consistently good results. Control of summer grass and whorled pigeon grass was more difficult. Nicosulfuron and rimsulfuron, when used with Ethokem, were effective at all growth stages on both grasses. Primisulfuron was less dependent on the use of adjuvants but had very little effect on summer grass after the 2-leaf stage. On whorled pigeon grass primisulfuron was more effective on the larger plants but maximum control was still only 50-70% with or without adjuvants. The effect of all three herbicides was to stop plant growth for a period of about two weeks following treatment. After this time the plant either regrew, often from new basal shoots, or died. This high level of regrowth occurred in the absence of any competition in the pots whereas in the field significant competition could be expected from both the crop and other weeds.

Field experiments. In the first field experiment wed emergence was very irregular which made correct timing of the post-emergence treatments difficult. This was reflected in the high variance of the dry matter production and consequently large l.s.d. values (Table 2). However, there were significant differences in the initial activity resulting from the use of adjuvants, in particular Ethokem. There were also differences in the spectrum of grasses present after treatment. When used alone or with crop oil, rimsulfuron failed to control both summer grass and smooth witchgrass but when used with either Pulse, Citowett or Ethokem, only summer grass remained. Primisulfuron failed to control most grass weeds except when used with either Pulse or Ethokem which helped to control smooth witchgrass. It was also more effective on broadleaf weeds. All treatments were well tolerated by the maize crop with no visual injury apparent at any stage and grain yields were not significantly different in any treatment from that of the standard alachlor treatment.

In Trial 2 the post-emergence treatments were applied earlier to weeds that were more uniform in size and the rate of rimsulfuron was increased to achieve better control of broadleaf weeds (Table 3). Rimsulfuron was more effective on broadleaf weeds, especially when used with either Ethokem or Citowett, but this also allowed more grasses to grow and in some treatments grass weed control was inadequate. More effective control of the broadleaf weeds (especially atrazine resistant fat hen, *Chenopodium album*) by primisulfuron when used with Ethokem also increased the amount of grass weeds in that treatment even though smooth witchgrass was controlled by this combination.

The results of both the pot and field experiments show that adjuvants can be used to improve the efficacy of sulfonylurea herbicides on some grass weeds. It may also be possible to achieve satisfactory control of grass weeds at an advanced growth stage by the use of an adjuvant. Overall, Ethokem provided the most consistent improvement to the efficacy of these three herbicides, although the other adjuvants proved equally effective in some cases.

REFERENCES

1. Beyer, E.M., Duffy, M.J., Hays, J.V. and Schlueter, D.D 1988. In: Herbicides: Chemistry, Degradation and Mode of Action, Vol. 3. (Eds P.C. Kearney and D.D. Kaufman) (Marcel Dekker Inc.: New York). pp 117-189.
2. Blair, A.M. and Martin, T.D. 1988. Pestic. Sci. 22, 195-219.
3. Brown, H.M. 1990. Pestic. Sci. 29, 263-281.
4. James, T.K. and Rahman, A. 1992. Proc. 1st International Weed Control Congress, Vol. 2. pp 229-232.
5. Kimura, F., Haga, T., Sakashita, N., Murai, S. and Fujikawa, K. 1989. Proc. Brighton Crop Prot. Conf. - Weeds. pp 29-34.
6. Martin, P.R. and Rahman, A. 1988. Proc. 41st NZ Weed and Pest Control Conf. pp 214-218.
7. Maurer, W., Gerber, H.R. and Rufener, J. 1987. Proc. 1987 British Crop Prot. Conf. - Weeds. pp 41-48.
8. Nalewaja, J.D. and Adamczewski, K.A. 1988. Weed Sci. 36, 296-300.
9. Nalewaja, J.D. and Woznica, Z. 1985. Weed Sci. 33, 395-399.
10. Nalewaja, J.D., Woznica, Z. and Mantley, F.A. 1991. Weed Technol. 5, 92-96.
11. Palm, H.L., Liang, P.H., Fuesler, T.P., Leck, G.L., Strachan, S.D. and Wittenbach, V.A. 1989. Proc. Brighton Crop Prot. Conf. - Weeds. pp 23-28.
12. Rahman, A. and James, T.K. 1993. Proc. EWRS Symposium on Quantitative Approaches in Weed and Herbicide Research and their Practical Application, Braunschweig, in press.