EFFICACY OF HERBICIDES AGAINST ANGLED ONION IN POT TRIALS

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Summary Angled onion (*Allium triquetrum* L.) is a bulbous perennial which is a weed of damp sites in urban areas and nearby bushland in southern Victoria. In a series of glasshouse pot trials 12 herbicides were evaluated for activity against angled onion. The most active herbicides were metsulfuron methyl, chlorsulfuron, thifensulfuron methyl/metsulfuron methyl, chlorimuron ethyl, tribenuron methyl, and imazethapyr, followed by glyphosate, glufosinate and 2,4-D amine and ester. Dicamba was less effective and fluroxypyr gave no control. Metsulfuron methyl, chlorsulfuron, and imazethapyr were ineffective without the addition of an adjuvant. Metsulfuron methyl and imazethapyr were enhanced more by the surfactants BS1000 and Pulse at concentrations of 0.5% v/v than at 0.1% v/v. Control by glyphosate at 180 g 100 L^{-1} was significantly improved by the addition of Pulse, Activator, BS1000 and LI-700, and Pulse conferred rainfastness on glyphosate. Control with 2,4-D amine was improved by Pulse and Activator but these two surfactants and BS1000 did not enhance glufosinate.

INTRODUCTION

Angled onion (*Allium triquetrum* L.) is a weed of damp sites in bushland and near-urban areas in southern Victoria. Bulbs and seed germinate in autumn, it flowers in late winter and early spring, and the foliage senesces in early summer. The only herbicides recommended for its control are kerosene, 2,4-D amine (Anon. 1983), 2,4-D ester and dicamba and there is no published information on the activity of the many newer herbicides on angled onion. This paper reports the results of eight glasshouse trials which evaluated 12 herbicides on angled onion.

MATERIALS AND METHODS

Angled onion was grown in pots in the glasshouse, either from seed or from seedlings collected in the field. Except for Trial 2 (in which plants were grown 6–8 per 25 cm diameter pot) plants were grown singly in 12–15 cm pots in a steam-sterilized potting mix consisting of three parts composted tan bark to two parts washed sand. At application the potting soil was moist. With the exception of Trial 3, spray application was made with a mechanical track sprayer in a spray cabinet. The moving boom had two flat fan nozzles spaced 50 cm apart and set at the required height above the plants to give a 1½ overlap pattern at the top of the foliage. In Trial 3 potted plants were arranged on the ground and sprayed, at a constant walking speed, with a 'Hudson' compression knapsack and a hand-held lance with a single nozzle. In Trial 8, after application, plants were placed in rain produced by a rainfall simulator at an intensity of 6 mm h^{-1} for a period of one hour. In all trials, after spraying the plants were returned to a glasshouse maintained at 20–25°C and not watered for 24 hours after application.

The details of each trial are given in Table 1.

Table 1. Trial details.

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7 and 8
Pot diameter	15 cm	25 cm	15 cm	15 cm	15 cm	15 cm	14 cm
Plants/pot	1	6–8	1	1	1	1	1
Replications	7	3	6	5	6	5	5
Nozzle size	SS 11001	SS 11003	SS 11002	SS 11001	SS 11003	SS 11003	SS 11003
Spray pressure	235 kPa	345 kPa	350 kPa	250 kPa	317 kPa	317 kPa	275 kPa
Spray volume	150 L ha^{-1}	541 L ha^{-1}	590 L ha^{-1}	173 L ha^{-1}	495 L ha^{-1}	492 L ha^{-1}	507 L ha^{-1}
Application method	Spray cabinet	Spray cabinet	Knapsack	Spray cabinet	Spray cabinet	Spray cabinet	Spray cabinet
Plant height	<=18 cm	<=40 cm	30–50 cm	31–60 cm	13–21 cm	22–35 cm	–
No. of leaves	3–5	6–8	12–30	7–10	3–5	16–28	5–17
Leaf length	24–48 cm	–	–	55–80 cm	22–42 cm	<=64 cm	31–52 cm
Growth stage	vegetative	vegetative	flowering	vegetative	vegetative	flowering	vegetative
Temp at application	–	–	30°C	18°C	17°C	16°C	18°C

RESULTS

Trial 1 Metsulfuron methyl at 2.4 g ha^{-1}, chlorsulfuron at 11.3 g ha^{-1} and imazethapyr at 25 g ha^{-1}, the lowest rate tested for each herbicide, killed all plants (Table 2). Glyphosate killed all plants at 2.16 kg ha^{-1}, while at 1.08 kg ha^{-1} two of the seven plants were not quite dead 49 days after treatment. Amine 2,4-D killed all plants at 4 kg ha^{-1}, and was as effective as 2,4-D ester at 3 kg ha^{-1}, but appeared less active than the ester at 2 kg ha^{-1}. Dicamba at the highest rate evaluated, 2.2 kg ha^{-1}, killed only four out of seven plants, while fluroxypyr at 0.9 kg ha^{-1} caused only slight damage.

Table 2. Effect of herbicides on angled onion 49 days after treatment in Trial 1.

Herbicide	Rate (g ha^{-1})	Control Score (0–10)[A]	Killed (%)[B]
Metsulfuron methyl[C]	2.4	10	100
Chlorsulfuron[C]	11.3	10	100
Imazethapyr[C]	25	10	100
Glyphosate	1080	9.7	71
Glyphosate	2160	10	100
2,4-D amine[C]	2000	8.7	43
2,4-D amine[C]	3000	9.6	86
2,4-D amine[C]	4000	10	100
2,4-D ester	2000	9.6	71
2,4-D ester	3000	9.9	86
2,4-D ester	4000	9.7	86
Dicamba[C]	600	0.9	0
Dicamba[C]	1400	4.4	0
Dicamba[C]	2200	7.6	57
Fluroxypyr	600	1.4	0
Fluroxypyr	900	2.3	0
Untreated	–	0	0
LSD (P=0.05)		1.1	

[A] 0 = No effect, 10 = dead. Mean of seven plants.
[B] Percentage of plants killed.
[C] BS1000 included at 0.1% v/v.

Table 3. Effect of herbicides on angled onion 45 days after treatment in Trial 2.

Herbicide[A]	Conc. (g 100 L^{-1})	Control Score (0–10)[B]	Killed (%)[C]
Metsulfuron methyl[D]	0.3	10	100
Metsulfuron methyl[D]	0.6	9.3	91
Clorsulfuron[D]	1.13	10	100
Clorsulfuron[D]	2.25	10	100
Glyphosate	144	1.3	0
Glyphosate	288	4.3	24
Untreated	–	0	0
LSD (P=0.05)		2.5	

[A] Applied in 541 L ha^{-1}.
[B] 0 = No effect, 10 = dead. Mean of three replications.
[C] Percentage of plants killed.
[D] BS1000 included at 0.15% v/v.

Trial 2 Treatments in this trial were applied in a higher volume (541 L ha^{-1}) to simulate spot-spray application. Metsulfuron methyl at 0.3 g 100 L^{-1} (1.62 g ha^{-1}) killed all treated plants, although at 0.6 g 100 L^{-1} two (out of 23) plants were still alive 45 days after application (Table 3). Chlorsulfuron at 1.13 g 100 L^{-1} (6.1 g ha^{-1}) killed all treated plants. Glyphosate at 288 g 100 L^{-1} (1.56 kg ha^{-1}) gave inadequate control.

Trial 3 Glyphosate and glufosinate were evaluated, in a higher volume application with a compression knapsack, on plants which were large and flowering. By 39 days after application glyphosate gave almost a total kill at 720 g 100 L^{-1}, while lower rates were slightly less effective, or slower in their effects (Table 4). Glufosinate at 300 g 100 L^{-1} killed all plants, but at lower rates, at least 50 per cent of plants were still alive at the final assessment.

Trial 4 This trial further evaluated four sulfonylurea herbicides. Sixty days after application metsulfuron methyl at 1.2 g ha^{-1} had given a complete kill, while at 0.6 g ha^{-1} control was almost complete (Table 5). The proprietary mixture of thifensulfuron methyl/metsulfuron methyl at 6.82 g/0.68 g ha^{-1} gave a high level of control, but not better than metsulfuron methyl alone at 0.6 g ha^{-1}. The lower rate of the mixture gave significantly less control (P=0.05) than the other treatments. Chlorimuron

Table 4. Effect of glyphosate and glufosinate on angled onion 39 days after application in Trial 3.

Herbicide[A]	Conc. (g 100 L^{-1})	Control Score (0–10)[B]	Killed (%)[C]
Glyphosate	360	9.3	83
Glyphosate	540	8.2	33
Glyphosate	720	9.9	83
Glufosinate	150	7.7	50
Glufosinate	225	7.3	33
Glufosinate	300	10	100
Untreated	–	0	0
LSD (P=0.05)		2.0	

[A] Applied in 590 L ha^{-1}.
[B] 0 = No effect, 10 = Dead. Mean of six replications.
[C] Percentage of plants killed.

ethyl killed all plants at 7.5 g ha^{-1}, and at 3.75 g ha^{-1} gave almost complete control. Tribenuron methyl at 11.25 g ha^{-1} killed all plants, although at 22.5 g ha^{-1} one plant survived.

Trial 5 Metsulfuron methyl, chlorsulfuron and imazethapyr were applied alone and with the surfactant BS1000 at 0.1% v/v. The highest rate of each herbicide was ineffective when applied without surfactant. The efficacy of all three herbicides was greatly enhanced by the surfactant (Table 6). Applied with BS1000, metsulfuron methyl at 0.3 g and 0.6 g ha^{-1} gave almost complete control and 1.2 g ha^{-1} gave a complete kill, chlorsulfuron at 1.5 g ha^{-1} gave a complete kill and imazethapyr at 24 g ha^{-1} gave almost complete control.

Table 5. Effect of sulfonylurea herbicides on angled onion 60 days after treatment in Trial 4.

Herbicide	Rate (g ha^{-1})	Control Score (0–10)[A]	Killed (%)[B]
Metsulfuron methyl	0.6	9.4	80
Metsulfuron methyl	1.2	10	100
Thifensulfuron methyl	3.41		
+ Metsulfuron methyl	0.34	4.8*	20
Thifensulfuron methyl	6.82		
+ Metsulfuron methyl	0.68	8.8	60
Clorimuron ethyl	3.75	9.8	80
Clorimuron ethyl	7.5	10	100
Tribenuron methyl	11.25	10	100
Tribenuron methyl	22.5	8.8	80
Untreated	–	0	0

[A] 0 = No effect, 10 = dead. Mean of five replications.
[B] Percentage of plants killed.
* Significantly different (P=0.05) from other treatments.

Table 6. Effect of herbicides with and without BS1000 surfactant on angled onion 42 days after treatment in Trial 5.

Herbicide	Rate[A] (g ha^{-1})	Control Score (0–10)[B] - BS1000	+ BS1000 (0.1%)
Metsulfuron methyl	0.3	0	9.3
Metsulfuron methyl	0.6	1.5	9.7
Metsulfuron methyl	1.2	1.7	10
Chlorsulfuron	1.5	–	10
Chlorsulfuron	2.6	0.3	10
Chlorsulfuron	3.8	–	10
Imazethapyr	12	0	1.5
Imazethapyr	18	0.2	7.8
Imazethapyr	24	0.3	9.7
Untreated	–	0	
LSD (P=0.05)	1.3		

[A] Applied in a spray volume of 495 L ha^{-1}.
[B] 0 = No effect, 10 = dead. Mean of six replications.

Trial 6 Four spray adjuvants were assessed for their effect on the efficacy of imazethapyr. The herbicide was applied at a spray concentration of 3.6 g 100 L^{-1} (equivalent to a rate of 17.7 g ha^{-1}), a rate which was shown in Trial 5 to be ineffective if applied without a surfactant and sub-optimal if used with BS1000 at 0.1% v/v. Imazethapyr applied alone, or with Codacide emulsifiable vegetable oil at 0.2% v/v, or D-C-Trate emulsifiable petroleum oil at 1% v/v gave no control 59 days after application (Table 7). BS1000 enhanced the effect of the herbicide, the effect being greater at 0.5% v/v than at 0.1% v/v. Pulse had no significant effect at 0.1% v/v, but gave a large improvement in control at 0.5% v/v.

Trial 7 This trial assessed the influence of various adjuvants on the efficacy of glyphosate, glufosinate, 2,4-D amine and metsulfuron methyl. Control with glyphosate at 180 g 100 L^{-1} was significantly enhanced (P=0.05) by Pulse at 0.2% v/v and 0.5% v/v, Activator at 0.125% v/v, BS1000 at 0.2% v/v and LI-700 at 0.5% v/v (Table 8). Glyphosate at 180 g 100 L^{-1} plus Pulse at 0.5% v/v tended to give higher control (P>0.05) than glyphosate alone at 360 g 100 L^{-1}. Codacide at 0.5% v/v did not significantly improve the efficacy of glyphosate. Glufosinate at 100 g 100 L^{-1} was ineffective and was not improved by BS1000, Pulse or Activator. Amine 2,4-D

Table 7. Effect of adjuvants on the efficacy of imazethapyr applied to angled onion at a concentration of 3.6 g 100 L^{-1} (17.7 g ha^{-1}) in Trial 6. Assessed 59 days after application.

Adjuvant	Conc. (%)	Control Score (0–10)[A]	Killed (%)[B]
No adjuvant	–	2.0	0
BS1000	0.1	4.9	0
BS1000	0.5	9.1	40
Pulse	0.1	2.2	0
Pulse	0.5	8.5	20
Codacide oil	0.2	2.0	0
D-C-Trate oil	1.0	2.0	0
Untreated	–	2.0	0
LSD (P=0.05)		1.9	

[A] 0 = No effect, 10 = dead. Mean of five replications.
[B] Percentage of plants killed.

at 200 g 100 L^{-1} had only a slight effect on angled onion, but was significantly improved (P=0.05) by both Pulse at 0.2% v/v and by Activator at 0.125% v/v. Metsulfuron methyl alone at 0.15 g and 0.3 g 100 L^{-1} had no visible effect on angled onion. The addition of either BS1000 or Pulse greatly increased control, and concentrations of 0.5% v/v had more effect than 0.2% v/v with metsulfuron methyl at 0.15 g 100 L^{-1}.

Trial 8 This trial assessed the effect of adjuvants on the rainfastness of glyphosate applied to angled onion. Without adjuvant, glyphosate efficacy was significantly decreased by simulated rain, even if delayed until six hours after application (Table 9). In the absence of rain, both Pulse and Activator enhanced the efficacy of glyphosate on angled onion. However with rain after application, only Pulse maintained the efficacy of glyphosate, and this was the case even when there was rain one hour after application.

Table 8. Effect of various adjuvants on the efficacy of glyphosate, glufosinate, 2,4-D amine and metsulfuron methyl 42 days after application to angled onion in Trial 7.

Herbicide	Conc.[A] (g 100 L^{-1})	Adjuvant and conc.(%)	Control Score (0-10)[B]
Glyphosate	180	–	3.0
Glyphosate	180	Pulse 0.2	5.2
Glyphosate	180	Pulse 0.5	9.2
Glyphosate	180	Activator 0.125	5.6
Glyphosate	180	BS1000 0.2	6.6
Glyphosate	180	LI-700 0.5	6.4
Glyphosate	180	Codacide 0.5	4.6
Glyphosate	360	–	7.4
Glufosinate	100	–	0.8
Glufosinate	100	BS1000 0.2	0
Glufosinate	100	Pulse 0.5	1.0
Glufosinate	100	Activator 0.125	0.8
2,4-D amine	200	–	1.2
2,4-D amine	200	BS1000 0.1	3.0
2,4-D amine	200	Pulse 0.2	4.2
2,4-D amine	200	Activator 0.125	4.4
Metsulfuron	0.15	–	0
Metsulfuron	0.15	BS1000 0.1	4.8
Metsulfuron	0.15	BS1000 0.2	6.8
Metsulfuron	0.15	BS1000 0.5	8.4
Metsulfuron	0.15	Pulse 0.2	6.8
Metsulfuron	0.15	Pulse 0.5	9.8
Metsulfuron	0.3	–	0
Metsulfuron	0.3	BS1000 0.1	9.8
Metsulfuron	0.3	BS1000 0.2	10
Metsulfuron	0.3	Pulse 0.2	10
Metsulfuron	0.3	Pulse 0.5	9.4
Untreated	–	–	0
LSD (P=0.05)		2.2	

[A] Applied in a spray volume of 507 L ha^{-1}.
[B] 0 = No effect, 10 = dead. Mean of five replications.

DISCUSSION

The herbicides with the most activity against angled onion were the sulfonylyureas and imazethapyr. Metsulfuron methyl gave complete control at 2.4 g ha^{-1} in the initial screening trial (Table 2). Further testing in Trials 2, 4, 5 and 7, (Tables 3, 5, 6 and 8) indicated that rates as low as 0.76 g ha^{-1} (0.15 g 100 L^{-1}, Table 8) could give complete control. Even at 0.6 g ha^{-1} (Tables 5, 6) and 0.3 g ha^{-1} (Table 6) very high levels of control were obtained. The necessity of including an adjuvant in the spray solution was shown in Trial 5 (Table 6), and in Trial 7 Pulse at 0.5% v/v or BS1000 at 0.5% v/v were found to have more effect than the same adjuvants at 0.2% v/v (Table 8).

The 10:1 proprietary mix of thifensulfuron methyl and metsulfuron methyl was evaluated in Trial 5. It was no more effective than metsulfuron methyl applied on its own at the same rate as in the mixture (Table 5).

Chlorsulfuron gave complete control of angled onion at 1.5 g ha^{-1} in Trial 5 (Table 6) after being effective at higher rates in Trials 1 and 2 (Tables 2 and 3). An adjuvant was essential for its activity (Table 6).

Table 9. Effect of adjuvants and simulated rainfall 1, 3 and 6 h after application on the efficacy of glyphosate applied at 180 g 100 L^{-1} in Trial 8. Assessed 85 days after application.

Adjuvant	Conc. (%)	No rain	Rain[A] after 6 h	3 h	1 h
			Control Score (0–10)[B]		
No adjuvant	–	5.6 (2.26)[C]	1.2 (0.49)	0 (0.00)	0 (0.00)
Activator	0.125	9.0 (2.99)	1.6 (0.73)	0.2 (0.83)	0.8 (0.57)
Pulse	0.5	10 (3.16)	8.4 (2.88)	9.4 (3.06)	9.4 (3.06)
Untreated	–		0 (0.00)		
LSD (P=0.05)			(0.82)		

[A] Rain at intensity of 6 mm hr^{-1} for 1 h.
[B] 0 = No effect, 10 = dead. Mean of five replications.
[C] Öx transformed values in parentheses.

Chlorimuron ethyl gave a complete kill at 7.5 g ha^{-1} and virtually complete control at 3.75 g ha^{-1} in Trial 4 (Table 5).

Tribenuron methyl gave complete control at 11.25 g ha^{-1} in Trial 4. However on smaller plants (3-5 leaves, 13-21 cm high) in another trial (details not shown) a complete kill after 42 days was given by rates of 3.75 g, 7.5 g and 11.25 g ha^{-1}.

Imazethapyr gave complete control at 25 g ha^{-1} in Trial 1 and a high level of control at 24 g ha^{-1} in Trial 5 (Tables 2 and 6). Lower rates in Trial 5 were less effective. Imazethapyr had no activity on angled onion unless an adjuvant was included in the spray (Table 6 and 7). Pulse at 0.5% v/v and BS1000 at 0.5% v/v were more effective than lower concentrations of these adjuvants, while Codacide and D-C-Trate were ineffective.

Glyphosate at 2.16 kg ha^{-1}, applied without additional adjuvant, gave complete control in Trial 1 (Table 2), and near complete control of very large plants at 2.12 kg ha^{-1} (360 g 100 L^{-1}) in Trial 3 (Table 4). At 1.56 kg ha^{-1} (288 g 100 L^{-1}) in Trial 2 it gave inadequate control (Table 3). However the adjuvants Pulse, Activator, BS1000 and LI-700 enhanced glyphosate efficacy in Trial 7 as did Pulse and Activator in Trial 8, to the extent that high levels of control were given by 0.9 kg ha^{-1} (180 g 100 L^{-1}) (Tables 8 and 9). Simulated rain within one hour of application did not significantly reduce control when Pulse, but not Activator, was included in the spray (Table 9).

Glufosinate without added adjuvant gave complete control at 1.77 kg ha^{-1} (300 g 100 L^{-1}) in Trial 3, but was less effective at lower rates. At 0.51 kg ha^{-1} (100 g 100 L^{-1}) in Trial 7 its efficacy was not significantly improved by any of the adjuvants tested (Table 8).

Of the herbicides currently recommended for the control of angled onion, dicamba was found to be unsatisfactory, even when applied at well above the label rate of 0.6 kg ha^{-1} (Table 2). Ester and amine formulations of 2,4-D at 2–4 kg ha^{-1} gave good, although not always complete control in Trial 1. The addition of adjuvants, particularly Pulse and Activator, were found to enhance the efficacy of 2,4-D amine in Trial 7 (Table 8) and in another trial (not included here) Pulse at 0.5% v/v with 2,4-D amine at 300 g 100 L^{-1} (1.55 kg ha^{-1}) gave complete control.

The results from these glasshouse trials indicate that several herbicides have the potential to give control of angled onion in the field at rates which should have a minimal impact on non-target species.

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REFERENCES

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