Herbicide control of summer-active perennial weeds in southern Australia

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Summary Perennial weeds are problematic to control due to the presence of both a seedbank and a rootbank. In addition, summer active perennial weeds generally require herbicides to be applied under hot, dry conditions, which are not conducive to good herbicide uptake and translocation. Applying herbicides under more favourable conditions in late summer or early autumn may lead to increased herbicide efficacy. Field experiments were conducted on silverleaf nightshade (*Solanum elaeagnifolium*) and prairie ground cherry (*Physalis viscosa*) investigating the effect of herbicide application time upon rootbank dynamics. The silverleaf nightshade rootbank was most effectively controlled when herbicides were applied in autumn prior to the weeds beginning senescence, while the prairie ground cherry rhizomes were controlled with herbicides applied in either summer or autumn. These results have significant implications for developing appropriate management packages for these weeds to achieve long term control. Similar approaches could be applied to other intractable perennial weeds

Keywords *Solanum*, *Physalis*, Solanaceae herbicide.

INTRODUCTION

Silverleaf nightshade (*Solanum elaeagnifolium* Cav.) and prairie ground cherry (*Physalis viscosa* L.) are deep-rooted, summer-growing perennial weeds of the Solanaceae family thought to be native to south-western USA and northern Mexico (Eleftherohorinos *et al*. 1993, Randall 2002). These weeds arrived in Australia in the early 1900s as a contaminant of grain and fodder (Parsons and Cuthbertson 2001), and remained a minor weed until rapid expansion occurred in the 1960s (Cuthbertson *et al*. 1976). Both of these weeds are declared noxious weeds in Australia and are difficult to eradicate once established due to their extensive root systems (Parsons and Cuthbertson 2001, Stanton *et al*. 2009).

Potential toxicity and low palatability restrict the usefulness of grazing to control of these weeds, although some livestock selectively graze on the mature fruits of prairie ground cherry. Mellado *et al*. (2008) reported that increasing percentages of silverleaf nightshade in the diet led to decreased dry matter intake and body weight gain in goats.

Cultivation is largely ineffective in Australia as most of the root system is below the cultivation zone. The reproductive capacity of silverleaf nightshade root and prairie ground cherry rhizome fragments and the potential for fragments to be relocated to new fields are additional problems with using cultivation.

To date, no effective and economic herbicide treatments for control have been developed, mainly due to the presence of extensive root or rhizome systems. Chemical control recommendations have traditionally focused on spray application at flowering to limit seed set. This approach has generally aimed to suppress large infestations, with eradication of smaller patches and colonies sometimes achieved (Parsons and Cuthbertson 2001).

Wassermann *et al*. (1988) reported that when picloram was applied to silverleaf nightshade in South Africa at rates above 264 g a.i. ha^{-1}, more effective control was achieved in autumn than in summer. Similarly, Greenfield (2003) reported that glyphosate translocation to silverleaf nightshade roots is greater in spring and autumn compared to summer, suggesting that time of application is critical for successful herbicide control of the rootbank.

Studies were conducted to evaluate the effectiveness and consistency of herbicide treatments for silverleaf nightshade and prairie ground cherry control when applied at different times of the season.

MATERIALS AND METHODS

Field experiments commenced in 2007 at two sites in southern New South Wales on natural silverleaf nightshade infestations with uniform densities of 7–10 stems m^{-2} and one prairie ground cherry site with an average density of 6 plants m^{-2}. One site was located near Leeton on a clay soil in a field formerly used for cropping under flood irrigation, and the second site was located near Culcairn on a hillside opportunistically sown to dryland crops or pastures. The prairie ground cherry field site was located near Tocumwal in a pasture field.

The experiments were conducted in a randomised complete block design with three replicates per site using plots measuring 4 × 10 m. Due to the potential of lateral roots penetrating between plots, measures were not taken within 1 m of the plot boundaries.

Herbicides were applied using a shielded 4 m boom fitted with Lechler IDK 120-015 low pressure air induction nozzles operated at 250 kPa to provide 100 L ha^{-1} spray volume. Uptake spray oil at 1% v/v was included as a standard adjuvant. Three herbicide treatments were compared: 1080 g a.i. ha^{-1} glyphosate (Roundup PowerMax™); 900 g a.i. ha^{-1} 2,4-D amine + 225 g a.i. ha^{-1} picloram (Tordon 75-D™); and 900 g a.i. ha^{-1} triclopyr + 300 g a.i. ha^{-1} picloram + 24 g a.i. ha^{-1} aminopyralid (Grazon Extra™). Herbicides were applied at flowering (December/January) and after berry maturity (late March) at the rates given above for the first three treatments. Two further treatments (Roundup PowerMax and Tordon 75-D) received the same herbicide rate as above at flowering only to replicate current recommended timing, and a further treatment was included as an unsprayed control.

Glyphosate was applied as required during winter for control of annual winter weeds while the summer weeds were senescent. Herbicide applications commenced in summer 2007/08 and were repeated the following season at all sites.

Weed densities were recorded from two 1 m^2 fixed quadrats on the centreline of each plot, commencing in December 2007 prior to treatments being applied. Stem density, growth stage and percent control were recorded prior to herbicide application and 6 weeks after treatment to evaluate within season control for herbicides applied at flowering. Stem density was recorded the following December to evaluate long term control achieved for all herbicide applications.

Homogeneity of variance was not improved by transformation, therefore analyses were performed on raw stem densities. Data variance was visually inspected by plotting residuals to confirm homogeneity of variance before statistical analysis. Data were analysed using analysis of variance and Fisher's Protected LSD at 5% level of significance used to separate treatment means.

RESULTS

No significant differences occurred between silverleaf nightshade sites, therefore combined data are presented. The early application of pyridine herbicides provided better control of aerial growth within season than glyphosate, averaging 73% mortality of aerial growth after a single application at flowering/early berry set (data not shown). The least number of new stems within season was observed in plots treated with pyridines, due to either better control of the root system or the residual action of the herbicide.

The long term control of silverleaf nightshade was highest when pyridine herbicides were applied twice during the season ($P < 0.01$, Table 1). Single application of long term control was increased for both glyphosate and pyridine herbicides when a second application of the same herbicide was made late in the season, although this difference was not significant compared to a single application of the same herbicide. Additional experiments have commenced to determine if the increased level of control is due to twice the amount of active ingredient being applied in the one season, or due to the time of application.

Table 1. Weed stem density (number $m^{-2} \pm$ SE) after 2 years of different herbicide treatments.

Weed	Treatment	Dec. 2007	Dec. 2009
Silverleaf nightshade	control	6.4 ± 2.1	11 ± 1.6
	Roundup PowerMax	9.8 ± 5.9	6.3 ± 1.8
	Roundup PowerMax twice	5.3 ± 1.2	3.9 ± 0.9
	Tordon 75-D twice	8.3 ± 3.0	1.6 ± 0.5
	Grazon Extra twice	5.8 ± 0.7	1.0 ± 0.4
	Tordon 75-D	4.3 ± 1.1	4.6 ± 1.0
	LSD (P = 0.05)	n.s.	3.5
Prairie ground cherry	Control	6.0 ± 3.0	2.4 ± 0.8
	Roundup PowerMax	6.2 ± 2.5	0 ± 0
	Roundup PowerMax twice	7.0 ± 3.4	0 ± 0
	Tordon 75-D twice	3.3 ± 1.5	0 ± 0
	Grazon Extra twice	3.5 ± 2.1	0 ± 0
	Tordon 75-D	6.8 ± 2.4	0 ± 0
	LSD (P = 0.05)	n.s.	0.6

Preliminary data collected for prairie ground cherry emergence in December 2009 suggest that all herbicide treatments provided effective control. However, dry conditions prior to the emergence counts may have contributed to the low stem numbers recorded in the control plots at this time in the season. The plots will need to be monitored to determine if there are any subsequent emergence events following summer rainfall. It appears that a wider range of herbicide options are available for control of prairie ground cherry compared to silverleaf nightshade. Glyphosate appears to be equally effective as the pyridine herbicides, providing land managers with a wider choice of herbicide, and also a much cheaper alternative.

DISCUSSION

Consistent long term control of perennial weeds is reliant upon control of the rootbank. Silverleaf emergence after two seasons of herbicide applications was reduced when picloram had been applied, either as a single application or as two separate applications during the season. However, the cost of picloram based products and the land use limitations imposed by the residual nature of picloram detract from the suitability of this treatment over wide areas. However, the effectiveness of the treatment would suggest this is a suitable management tactic for isolated plants or populations, particularly if they are on areas such as roadways or fencelines where the residual nature of the product will have limited impact on the use of the land.

Greenfield (2003) indicated that season had a larger impact on glyphosate efficacy than rate, penetrant or the use of 2,4-D amine as a partner herbicide. In this study, fewer silverleaf nightshade stems emerged in the final season when herbicides had been applied in autumn compared to being applied in summer only. However, further research using autumn only herbicide treatments is required to verify that the improved control is a result of seasonal timing rather than a double spray application.

Gorrell *et al.* (1988) determined that picloram was more effective than dicamba or triclopyr for the control of horsenettle (*S. carolinense*). Similar amounts of all three herbicides were translocated to untreated shoots and roots, and it was concluded that the difference in control was attributable to the comparative potency of the active ingredients.

These studies show that herbicide management of summer active perennial weeds needs to be revised to achieve effective long term control of the rootbank. Current herbicide recommendations (Kidston *et al.* 2007, Ensbey 2009) suggest herbicide application at flowering or early berry set. While this time of application can provide good control of aerial growth within season and therefore manage input into the seedbank, it is not the optimum time of application to control the rootbank. Herbicide label recommendations need to be reviewed to provide for an autumn application to effectively target the rootbank to achieve long term control of summer active perennial weeds. Autumn applications also provide flexibility of herbicide application timing for control of rhizomatous summer perennial weeds.

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