Evaluating the extent of serrated tussock (*Nassella trichotoma*) resistance to the herbicide, Flupropanate in Australia.

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Summary Identification of a population of *Nassella trichotoma* resistant to the herbicide flupropanate just north-west of Melbourne has previously prompted a mail survey of 5000 land managers impacted by *N. trichotoma* across Australia. Out of 400 respondents, 9 reported *N. trichotoma* resistance to flupropanate and 6 reported resistance to glyphosate. Follow up testing of suspected properties has now confirmed 3 properties with *N. trichotoma* resistance to flupropanate. This study has also developed a relatively quick seed bioassay technique for testing for resistance. The extent of *N. trichotoma* resistance to flupropanate identified in this survey flags serious concern about its future viability as a management tool. This study emphasises the importance of promoting integrated management of *N. trichotoma* to help combat resistance.

Keywords: Serrated tussock, resistance, flupropanate.

INTRODUCTION

Serrated tussock (*Nassella trichotoma* (Nees) Hack. ex Arechav) is a Weed of National Significance (Thorp and Lynch 2000) causing huge agricultural and environmental impacts to Australia (McLaren *et al.* 1998). The potential distribution of serrated tussock based on its current infestations in Australia has been estimated at 32 million ha with substantial areas of New South Wales, Victoria and Tasmania at risk of invasion (McLaren *et al.* 1998).

The only registered herbicides for control of serrated tussock in pastures are flupropanate, glyphosate and 2,2-DPA. Flupropanate is widely regarded as the most selective and effective herbicide for controlling serrated tussock (Campbell and Vere 1995). It is classified by as a Group J herbicide that inhibits plant lipid synthesis and is regarded as a relatively low risk herbicide for resistance (Croplife Australia 2007). Flupropanate is a soil active herbicide that can have a residual activity and can prevent serrated tussock from regrowing for three to five years (Campbell and Vere 1995).

Flupropanate resistance has been identified in a population of serrated tussock in Victoria with serrated tussock surviving application rates as high as 8 L ha^{-1}, which is four times the recommended rate used for controlling this species (Noble 2002). A national serrated tussock resistance survey was undertaken by the Victorian Department of Primary Industries during 2004 to determine the extent of resistance in Australia (McLaren *et al.* 2006). This paper reports an assessment of 3 of 9 suspected flupropanate resistant serrated tussock populations identified from the 2004 survey compared to a known flupropanate susceptible population.

Petri dish seed bioassay techniques are commonly used to screen weed seeds for herbicide resistance (Beckie *et al.* 2000). We developed a sensitive Petri dish bioassay based on serrated tussock shoot growth for detecting differences in the response of serrated tussock to flupropanate.

MATERIALS AND METHODS

Serrated tussock seed collections were made from a known flupropanate resistant population from Diggers Rest, Victoria (37°39' 144°41'), a known susceptible population from St Albans Victoria, (37°45' 144°47') and from suspected flupropanate resistant populations in the Rowsely Valley, Victoria (37°41' 144°21') and in Armidale, NSW (30°32' 151°36'). The known and suspected resistant populations all had histories of 6-8 applications of flupropanate over a long period (15 to 20 years). Seed from the Diggers Rest site was obtained from known resistant glasshouse grown plants. At each of the other locations, seed was collected from 10-20 individual serrated tussock plants. For each site, the seed was then bulked together and the most viable seed was selected by choosing well-formed seeds that were firm when squeezed with moderate pressure with tweezers. For each treatment, 30 seeds were placed onto a 9 cm diameter Schleicher & Schuell no. 5703 filter paper inside a plastic Petri dish. 5.0 ml of treatment flupropanate solution was applied to the seeds in each Petri dish. Individual flupropanate treatments

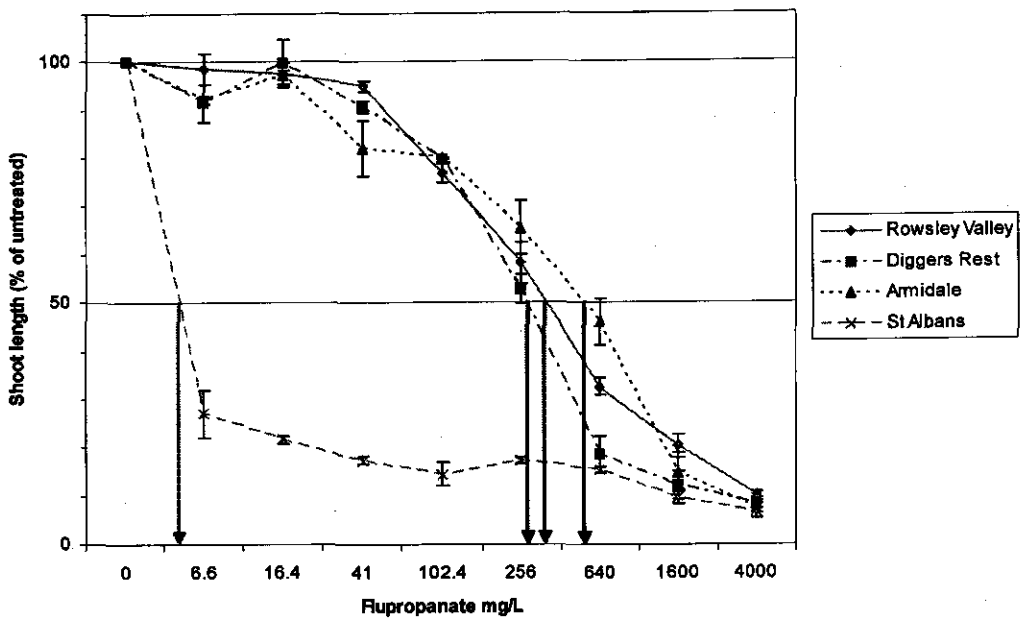

Figure 1. Mean ± Standard error shoot length (% of untreated control) affected by flupropanate concentration for four seed collections of serrated tussock after 18 days germination in petri dishes. Arrows were used to calculate treatment GR50s (dose required to give a 50% reduction in shoot growth).

were applied to the seeds at concentrations of 0, 6.6, 16.4, 41.0, 102.4, 256, 640, 1600 and 4000 mg L^{-1}. Each treatment was replicated three times. After application the Petri dishes were placed in a germination cabinet at 25/15 °C (12/12 hr light/dark) and had their locations rotated at random every 4 days. Petri dishes were checked daily for hydration and 5ml of distilled water was applied to all Petri dishes on day 12. However, 5 of the 108 Petri dishes did dry out and these were excluded from the analysis. Shoot length was measured 18 days after treatment application. Only germinated seedlings were measured for their height and included in the analysis. Flupropanate-stunted serrated tussock seedlings did not regrow and died.

RESULTS

In comparison to the untreated controls, germinated seedlings from St Albans were significantly shorter (susceptible) than those from Diggers Rest, Rowsley Valley and Armidale (resistant) when treated with flupropanate at rates from 6.6 mg L^{-1} to 256 mg L^{-1} (Figure 1). The differences in shoot length between resistant and susceptible populations were greatest between flupropanate concentrations of 16 and 40 mg L^{-1} (Figure. 1). The GR50 (dose required to give a 50% reduction in shoot growth) for the susceptible St Albans serrated tussock seedlings was approximately 4.7 mg L^{-1} compared with 280 mg L^{-1} for Diggers Rest, 370 mg L^{-1} for Rowsley Valley and 500 mg L^{-1} for Armidale seedlings respectively (Figure 1). These are 64, 69 and 105 times the GR50 flupropanate dose for the susceptible St Albans seedlings (figure 1). In comparison to the untreated seed, germination of flupropanate-treated seed across all treatments declined by 5.5% (Rowsley Valley), 12.7% (Diggers Rest), 1.9% (Armadale) and 26.9% (St Albans) (Table 1).

Table 1. Effect of flupropanate serrated tussock seed germination compared across locations.

LOCATION	% Seed Germination	
	Untreated	Treated
Rowsley Valley	94.4	88.9
Diggers Rest	83.3	70.6
Armidale	46.6	44.7
St Albans (susceptible)	53.3	26.4

DISCUSSION

This study has confirmed that there are now at least three properties in Australia with serrated tussock resistant to flupropanate. This is of serious concern as flupropanate is widely regarded as the most effective and selective herbicide for serrated tussock control (Campbell and Vere 1995). Herbicides that have long soil residual and season-long control of germinating weeds characteristically increase selection pressure and the likelihood of resistance (Warwick 1991). Flupropanate has these characteristics, with a single flupropanate application preventing serrated tussock regrowing for three to five years (Campbell and Vere 1995). We propose that the continued use of flupropanate over a long time period (15-20 years) has resulted in flupropanate resistance developing independently at the Diggers Rest, Rowsley Valley and Armidale locations.

The Petri dish bioassay technique used in this trial showed that flupropanate-resistant serrated tussock seed from Diggers Rest, Rowsley Valley and Armidale could be reliably differentiated from susceptible seed from St Albans at concentrations from 16 mg L^{-1} to 102 mg L^{-1} in 18 days. This is far quicker than conventional testing of mature plants, as flupropanate is slow acting and treated plants may not respond for 3 to 12 months (Parsons 1992).

It is critical that land managers do not rely solely on one herbicide type to control serrated tussock. Land managers need to consider mechanical control, cropping, pasture rehabilitation, grazing management and strategic use of herbicides to try and reduce the likelihood of resistance. The findings of this study reinforce the need to practice integrated weed management to control serrated tussock. The implications of serrated tussock herbicide resistance is its increased dominance as a weed, increased costs for land managers, more herbicide usage and higher environmental pollution as a consequence. It is now appropriate to undertake serrated tussock flupropanate-resistance paddock surveys around the properties identified in this study to determine the extent of resistance and take appropriate remedial actions.

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