Herbicide resistance in perennial pasture systems – The ostrich has bolted

Jo Powells[1]

[1] Local Land Services, 1-3 Sharp Street, Cooma, NSW 2630, Email: https://www.lls.nsw.gov.au/regions/south-east

Abstract
Herbicide resistance is well documented in cropping systems but far less is known about the issue in perennial pastures. Perennial grass weeds such as serrated tussock (*Nassella trichotoma*) and African lovegrass (*Eragrostis curvula*) are particularly problematic in the Southern Tablelands of NSW, with minimal herbicide options available for control. Following the identification of widespread resistance to flupropanate in serrated tussock on the Monaro in 2017, seed samples from African lovegrass were collected in Autumn 2020 from locations across the northern and central Monaro region and subsequently tested for resistance to flupropanate. Testing identified plants at multiple locations with low-high resistance levels as well as sites with plants still susceptible to flupropanate at the higher label rate (3L/ha). Testing using lower rates of flupropanate (1.25-1.5L/ha) identified reduced efficacy of the herbicide in plants from some locations. These results present further challenges for land managers struggling to control African lovegrass in pastures.

Keywords
African lovegrass, serrated tussock, herbicide resistance, testing.

Introduction
There has been an exponential increase in the occurrence of herbicide resistance in weeds since 1975 (WeedScience.org 2021) and whilst the cropping sector has been managing these issues since the 1970s, managers of pasture-based systems have only had to contend with the issues since the early 2000s (Noble 2002).

Since their introduction into the country over 100 years ago. the perennial grasses serrated tussock (*Nassella trichotoma*) and African lovegrass (*Eragrostis curvula*) have posed ongoing challenges to graziers in their pasture systems in the tablelands of NSW. The group J herbicide flupropanate, has been and remains to be the most widely used chemical for control of these species. However, it is this over-reliance on a single herbicide that has driven the development of herbicide resistance. McLaren et al. (2008) noted that the continual use of group J herbicides (e.g. flupropanate) for more than 15-20 years has resulted in the development of herbicide resistant serrated tussock.

A survey investigating the extent of herbicide resistance in serrated tussock in 2004 identified three sites (two in Victoria and one in New South Wales) where flupropanate resistance had developed (McLaren et al. 2008). This was the first finding of herbicide resistance in a weed found predominantly in perennial pastures and prompted further investigations into the plant's biology and other herbicide control options.

Following the identification of herbicide resistant serrated tussock, McLaren et al. (2010) surveyed a 5 km radius around the 3 known serrated tussock resistance sites and found that the resistance had become widespread. They concluded that land managers were going to have to increasingly deal with the issue of herbicide resistance now that the resistance "genie" was out of the bottle.

The Monaro
Local archived reports indicate that NSW Agriculture commenced serrated tussock control trials using flupropanate in the late 1970s to early 1980s near Dalgety on the Monaro. The herbicide remains in common use today across Australia. Monaro land managers raised concerns about the efficacy of their flupropanate use in 2016, resulting in Local Land Services undertaking a multi-year project to test

resistance to herbicides in serrated tussock grass. Herbicide resistance in African lovegrass was then investigated in 2020 following increasing concerns about management of the weed that was rapidly spreading across the Monaro.

Methods

Serrated Tussock

In 2016, an initial thirteen samples of serrated tussock seed were collected from across the Monaro region. This seed was sent to Plant Science Consulting (South Australia) and germinated with the seedlings sprayed with Taskforce (745g ai Flupropanate) at the equivalent rates of 1.25, 2 and 3 L/ha. Wetting agents were not used. Assessment of the effectiveness of herbicide control was made nine weeks after treatment based upon the percentage of plants surviving in herbicide treatments compared to the control. The control seedlings grew strongly, so any reduction in growth was attributed to the impact of herbicide.

The following year, in an effort to identify just how widespread the herbicide resistance issue may be across the region, a further forty-six seed samples were collected from additional locations across the Monaro. The same methodology used in 2016 was repeated for this year's sampling and testing.

African lovegrass

Seeds from mature African lovegrass plants were collected from twelve sites in autumn 2020 from the northern and central areas of the Monaro where lovegrass populations are dense. Plant Science Consulting germinated these seeds and then sprayed the seedlings at the four-leaf stage with flupropanate (Taskforce) at the equivalent rates of 1.25, 2 and 3 L/ha (no wetter was added). Assessment of the effectiveness of herbicide control was made four weeks after treatment by comparing plant survival of the herbicide treated plants against the control plants.

Results

Serrated Tussock

In year one, five of the thirteen samples were found to have a high level of resistance to flupropanate with these samples originating from north and western areas of the Monaro. Increasing the rate of application of flupropanate from 1.25 to 2 and 3 L/ha did not significantly improve the control of these resistant biotypes which confirmed the high-level of resistance. The remaining eight samples were found to be susceptible to flupropanate.

In the second year of testing, twenty-three of the forty-six locations sampled tested had a high level of resistance to flupropanate. Fifteen further locations were identified as developing resistance and eight locations were still susceptible to the herbicide. For the locations where resistance was identified, increasing the rate of flupropanate application from 1.25-3 L/ha only resulted in small increases in control in most instances (e.g. 50 % control at 1.25 L/ha, 70 % control at 2 L/ha and 80 % control at 3 L/ha). However, a sample from one location showed no control at any applied rate of flupropanate.

The more widespread sampling of locations across the district revealed that localities with historical and higher densities of serrated tussock and a longer historical use of flupropanate, generally had higher instances of herbicide resistance. However, locations with plants still susceptible and with those identified as developing resistance to flupropanate were scattered across the Monaro region.

Table 1. Combined results for seed testing for flupropanate resistance in serrated tussock (2016-2018) and African lovegrass (2020) populations collected from the Monaro region of NSW.

	Resistance	Developing resistance	Susceptible	Total sites tested
Serrated Tussock	28	15	16	59
African Lovegrass	5	3	4	12

African lovegrass

Five of the twelve locations where African lovegrass was collected were found to have strong resistance to flupropanate (Table 1). A further three locations showed low to mid-level resistance and four locations were identified as still being susceptible to the herbicide (at the 3 L/ha rate). At those locations where developing resistance was identified, a response in application rate was noted with 50-90 % of treated plants surviving at the lower flupropanate application rates of 1.25 and 2 L/ha. Plant survival at these sites decreased to 40-55 % when treated at the 3 L/ha rate.

Discussion

The confirmation of flupropanate resistance in serrated tussock confirmed some land managers' concerns about resistance in the weed populations that they were attempting to control. Many of the land managers involved in the survey had blamed their poor weed control outcomes on recent higher than average rainfall events, or on poor spray application or both. By using the herbicide resistance testing process, variables affecting herbicide control outcomes in these weeds - such as rainfall, soil type, water quality, application rate and temperature - were all able to be controlled giving, clear indications about herbicide resistance.

The high number of sites where herbicide resistance was found in serrated tussock came as a shock to many land managers. However, the weed has a long presence in the Monaro region and historical NSW Agriculture records indicate that herbicide control using flupropanate commenced back in the late 1970s. McLaren et al. (2008) noted that after fifteen to twenty years of continual use of group J herbicides, resistance should be expected to have developed. Given the over forty years use of this herbicide in the region, the results found should not be surprising with local reaction to the findings most likely a reflection of the lack of awareness of herbicide resistance in pasture-based systems.

Figure 1. African lovegrass from a flupropanate susceptible location (left) and resistant location (right). Treatments (left to right) were nil, 1.25, 2 and 3 L/ha flupropanate (Images: Plant Science Consulting).

The African lovegrass results showed similar patterns to the serrated tussock results with a mixture of resistant, developing resistance and susceptible populations identified (Figure 1). The herbicide susceptible sites were generally located in areas with less history of flupropanate usage, however the herbicide resistance sites had a mixture of weed control histories.

Label rates for flupropanate use on serrated tussock in NSW are 1.5-2 L/ha and 1.5-3 L/ha for African lovegrass (APVMA PER9792). Lower rates of the herbicide are recommended for lighter soil types and in situations where desirable species or only young weed seedlings are present. It is worth noting that the sites where some degree of resistance was found, the rate of plant survival was much higher at low rates of herbicide application for both serrated tussock and African lovegrass. Increases in plant control were achieved when the application rate increased (up to 3 L/ha). These results are concerning given the recommendation (both on label and in recent trials) for using lower rates of herbicide (down to 1 L/ha) to control these weeds.

If low rates of flupropanate are continually used over large populations of perennial grass weeds without the follow-up control of surviving plants, we are likely to see a rapid increase of herbicide resistant populations. Ramasamy et al. (2010) found that serrated tussock plants primarily self-fertilised and that serrated tussock plants resistant to flupropanate would go on to produce at least 85–90 % herbicide resistant seeds. This rate of self-replication indicates that once a resistant population of serrated tussock has developed, it is likely to keep increasing in the absence of a change in control tactics. Possible dilution of the resistant gene pool by introducing susceptible plants is unlikely to yield significant changes in populations of herbicide controllable plants.

Conclusion

The "head in the sand" approach to managing herbicide resistance in pasture systems has resulted in the development of resistance to a key herbicide in both serrated tussock and African lovegrass. Despite warnings from researchers who had identified three separate populations of flupropanate resistant serrated tussock back in the early 2000s, little has changed in the management of perennial grass weeds in pasture systems.

The confirmation of flupropanate resistance in serrated tussock (Powells 2018) and African lovegrass would not come as a surprise to those familiar with weed ecology and the development of herbicide resistance. What is now needed is a focused and comprehensive approach to more carefully apply integrated weed management principles and at the same time begin looking at additional chemistries and control options for perennial grass weeds.

In the more challenging parts of the landscape, control of perennial grass weeds may never be cost-effective for an individual land manager. However, the true environmental cost of not taking action and allowing the degradation to spread onto the more manageable and productive landscapes cannot be overstated.

These results have significant implications for how serrated tussock and African lovegrass are managed not only the Monaro, but also in other tablelands perennial pasture systems into the future. They reinforce the need for integrated approaches to be taken for the control of perennial grass weeds and the importance of herbicide resistance testing in pasture systems. Unfortunately, the ostrich approach to managing herbicide resistance in pasture systems has meant that the genie is out of the bottle, and the horse has truly bolted.

References

McLaren DA, Merton E, Pritchard G, Grech C. and Bonilla J. (2008). Evaluating the extent of serrated tussock (Nassella trichotoma) resistance to the herbicide, flupropanate in Australia. Proceedings of the 16th Australian Weeds Conference, eds R.D. van Klinken, V.A. Osten, F.D. Panetta and J.C. Scanlan, pp. 94-6. (Queensland Weeds Society, Brisbane).

McLaren DA, Grech CJ, Bonilla J, Butler K and Ramasamy S. (2010). "Serrated tussock resistance to flupropanate in Australia – is the genie out of the bottle?", Seventeenth Australasian Weeds Conference. (http://caws.org.nz/old-site/awc/2010/awc201012661.pdf)

Noble S. (2002). An investigation into the herbicide resistance of serrated tussock. Honours thesis, Department of Applied Biology and Biotechnology, RMIT University, Victoria, pp. 1-84.

Powells J (2018). Flupropanate resistant serrated tussock (Nassella trichotoma) identified at multiple locations in the Monaro, New South Wales. Proceedings of the 21st Australasian Weeds Conference, Sydney NSW. (http://caws.org.nz/old-site/awc/2018/awc201813971.pdf)

Ramasamy S, McLaren DA, Preston C and Lawrie A. (2010). Heritability of flupropanate resistance in *Nassella trichotoma*. In Seventeenth Australasian Weeds Conference (pp. 210-273).

WeedScience.org (2021). Chronological Increase in Resistant Weeds Globally. (http://www.weedscience.org/Pages/ChronologicalIncrease.aspx)