Spot application of flupropanate results in high mortality of *Sporobolus pyramidalis*

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Summary Liquid flupropanate applied by spot application was tested on *Sporobolus pyramidalis* (P.Beauv.) to expand control options. Spot application is a high concentration, low volume herbicide mix applied directly into the base of the plant tussock. This application technique is suitable for herbicides such as flupropanate due to it being a predominantly root uptake herbicide and therefore complete foliage coverage is not needed. Applying liquid flupropanate by spot application provides a non-broadcast, species selective herbicide option with limited/no off-target damage. It is a practical method for scattered infestations within pastures, natural areas, roadsides and revegetation sites. The minimal equipment needed also allows plants to be controlled in hard to access areas.

Two trials were conducted on different properties within the Gladstone region. Liquid flupropanate (Taskforce® (745 g L^{-1} flupropanate)) was applied at rates of 0.149, 0.2235 and 0.298 g a.i. $tussock^{-1}$ and the efficacy was assessed against an untreated control. In both trials, all liquid flupropanate treatments were found to be effective for the control of *S. pyramidalis*, with 97.8% or higher mortality and no reproductive stems present during the following growing season.

Keywords flupropanate, spot application, giant rat's tail grass, *Sporobolus pyramidalis.*

INTRODUCTION

Sporobolus pyramidalis (P.Beauv.) is included in a group of highly invasive grasses present in Australia known as weedy Sporobolus grasses (WSG). Grasses include *Sporobolus natalensis* ((Stued.) T.Durand & Schinz), *Sporobolus jacquemontii* (Kunth), *Sporobolus africanus* ((Poir.) Robyns & Tournay) and *Sporobolus fertilis* ((Steud.) W.D Clayton). WSG are perennial tussock grasses that can quickly dominate a pasture and exclude native plants, leading to a loss of biodiversity. These grasses are prolific seeders and have low palatability when mature, which can have a major impact on the profitability of the grazing industry.

The seeds of WSG are primarily spread through vehicle and animal movement and in waterways (Bray & Officer, 2007). In Queensland, WSG are restricted invasive plants under the *Biosecurity Act 2014*. This means a person must not release them into the environment, give away or sell and take all reasonable and practical measures to reduce the spread (Department of Agriculture and Fisheries, 2021). WSG will grow in a wide range of soil and climate conditions and have the potential to grow in areas with a minimum average annual rainfall of 500 mm.

Glyphosate and flupropanate are currently the only herbicides permitted to be used on WSG (Vogler, 2010). Glyphosate is a non-selective systemic herbicide whilst flupropanate is a selective systemic herbicide with residual activity. Flupropanate has low contact activity and requires rainfall to allow the herbicide to enter the soil and be absorbed through the plants root system (Vee Dri (Aust) Pty. Limited, 2011).

Spot application is a low volume, high concentration application method for applying flupropanate on isolated and scattered plants and has been found to be effective on previously tested species; *Cenchrus polystachios* ((L.) Morrone), *Andropogon gayanus* (Kunth) (Vogler et al, 2017) and *Cenchrus setaceus* ((Forssk.) Morrone) (Vogler unpublished data). Spot application applies a shot of concentrated herbicide and water solution directly into the base of the tussock. This application method is ideal for flupropanate due to it being predominantly a root uptake herbicide making complete foliar coverage unnecessary. Spot application eliminates the need for bulky equipment (e.g. hoses and water tanks) and only uses a 5 L backpack and N.J Phillips® 5 mL Metal Tree Injector. One 5 L backpack would be able to treat up to 1000 plants. Minimal equipment allows a practical application method for hard to access areas.

These trials aim to determine if this method of application of liquid flupropanate is effective for controlling *S. pyramidalis*. Spot application was tested with different rates of liquid flupropanate in a replicated trial at two different locations. Granular flupropanate was not tested in these trials as spot application of granular flupropanate is already a registered control method on the label and under Minor use permit PER83249 (APVMA, 2017).

MATERIALS AND METHODS

Two field trials were established in the Gladstone region to determine effective spot application rates of liquid flupropanate for the control of *S. pyramidalis*. Site 1 was set up in December 2018 on a cattle property approximately 28 km northwest of Calliope (23º51'40.71''S, 151º02'16.69''E). At the time of treatment, *S. pyramidalis* had a medium density throughout the treatment area. Other grass species present at the site included *Themeda triandra (Forssk.)*, *Heteropogon contortus ((L.) P.Beauv. ex Roem. & Schult)*, *Bothriochloa bladhii ((Retz.) S.T.Blake)*, *Bothriochloa pertusa ((L.) A. Camus)* and *Hyparrhenia rufa* ((Nees) Stapf)). The soil is a silty alluvial soil with an acidic mottled hard B horizon (Queensland Government 2019). Cattle were excluded from the site for the duration of the trial.

Site 2 was set up in December 2019 on a cattle property, approximately 44.5 km southwest of Calliope (24º17'59.30''S, 151º03'28.91''E). At the time of treatment *S. pyramidalis* was the predominant species in the area. All other species had been eaten to ground level with patches of bare soil. The soil is an acidic sandy granitic soil with a mottled hard B horizon (Queensland Government 2019). Due to operational constraints, cattle were present in the area for the duration of the trial.

Both trials used a randomised complete block design. Site 1 had four treatments with five replicates and Site 2 had three treatments with four replicates. Liquid flupropanate (Taskforce® (745 g L^{-1} flupropanate)) was tested at three rates for Site 1 (0.149, 0.2235 and 0.298 g a.i. $tussock^{-1}$) on individual tussocks for efficacy against an untreated control. At Site 2, only the lower two rates were tested against an untreated control (Table 1). The number of tussocks per plot ranged from 9-22 and 13-50 tussocks at Site 1 and Site 2 respectively and were dependent on the number of plants in identifiable clumps of *S. pyramidalis*. All tussocks within the plots were treated and assessed. Plots were marked with wooden pickets (Site 1) or sections of poly pipe secured to the ground with a tent peg (Site 2).

Flupropanate treatments were applied with a N.J Phillips® 5 mL Metal Tree Injector or a N.J Phillips® 20 mL Metal Forestry Applicator (Figure 1). Both devices were attached to a N.J Phillips® 5 L backpack and were set to deliver a 4 mL shot via a stream into the centre of the base of each tussock. All *S. pyramidalis* tussocks within the plot were treated and each tussock received a single 4 mL shot of herbicide/water solution, regardless of plant size (e.g. 0.2 mL of herbicide product and 3.8 mL of water). Treated *S. pyramidalis* tussocks basal diameter ranged from 2.5 to 15 cm at Site 1 and 5 to 20 cm at Site 2.

Assessments Site 1, herbicide efficacy was assessed at five months after treatment (5 MAT) in April 2019 and Site 2 was assessed eight months after treatment (8 MAT) in June 2020. For both sites, each tussock was given a health rating from 1-4, where: 1 = appeared dead (0% green), 2 = unhealthy (> 0 – 10% green), 3 = relatively healthy (> 10 – 50 % green), 4 = healthy (> 50% - 100% green). The number of reproductive stems for each plot was also recorded. Analysis was conducted on the mean health rating, mean tussock mortality (%) and the mean number of reproductive stems per tussock to investigate treatment effects on reproductive output.

Statistical analysis Randomised complete block ANOVA and Fisher's Protected Least Significant Difference Test (LSD) were used to determine significant treatment effects for mean tussock health ratings. Tussock mortality (%) is presented as the treatment mean plus or minus the standard error of the mean.

Figure 1. N.J Phillips® 5 mL Metal Tree Injector (L) and N.J Phillips® 20 mL Metal Forestry Applicator (R).

RESULTS

There was a significant treatment effect (P<0.001) on the health rating of *S. pyramidalis* tussocks at both sites. All flupropanate treatments had greater than 97.8% mortality with no tussock mortality observed in the control treatment at both sites (Table 1). Tussocks that were still alive in the flupropanate treatments had a health rating of two with only one or two green stems remaining. The untreated control plots had a mean of 6.35 and 7.26 reproductive stems per tussock at Site 1 and Site 2 respectively. No other treatments at either site had reproductive stems.

The closest Bureau of Meteorology weather station to Site 1 is located at Mt Larcom (9 km away). This station recorded 353 mL of rainfall during the trial period (December 2018 to April 2019) compared to the long-term median rainfall for December to April at Mt Larcom which is 421 mL (Bureau of Meteorology, 2021a). The closest Bureau of Meteorology weather station to Site 2 is located at Rowanlea (5 km downstream). This station recorded 637.4 mL of rainfall during the trial period (October 2019 to June 2020) compared to the long-term median rainfall for October to June at Rowanlea which is 572.2 mL (Bureau of Meteorology, 2021b).

Table 1. Impact of spot application of liquid flupropanate at different rates on *S. pyramidalis* at both sites at time of assessment.

Site	Treatment	Rate (g a.i. tussock^{-1})	Product applied per tussock	Mean tussock health rating	Mean tussock mortality (%)
1	Control	0	NA	4 ± 0b	0 ± 0
	Flupropanate (745 g/L)	0.149	0.2 mL of Taskforce + 3.8 mL of water	1 ± 0a	100 ± 0
		0.2235	0.3 mL of Taskforce + 3.7 mL of water	1.02 ± 0.2a	98 ± 2
		0.298	0.4 mL of Taskforce + 3.6 mL of water	1.022 ± 0.0137a	97.77 ± 1.369
2	Control	0	NA	3.95 ± 0.05b	0 ± 0
	Flupropanate (745 g/L)	0.149	0.2 mL of Taskforce + 3.8 mL of water	1 ± 0a	100 ± 0
		0.2235	0.3 mL of Taskforce + 3.7 mL of water	1.016 ± 0.0156a	98.44 ± 1.562

Means are followed by plus or minus the standard error of the mean (SEM). For the mean health rating at each site, values followed by the same letter are not significantly different (P<0.05) according to Fisher's Protected LSD test (Site 1 LSD = 0.03963, Site 2 LSD = 0.0996).

DISCUSSION

Spot application of flupropanate was found to be effective for the control of *S. pyramidalis*, with 97.8% or higher mortality and no reproductive stems present for all flupropanate treatments at both sites. The few surviving tussocks in the flupropanate treatments only had one or two green stems remaining. The untreated controls had no mortality of *S. pyramidalis* at both sites and reproductive stems were present. From these trials, the method of spot application would be beneficial in the management and control of *S. pyramidalis*.

Minimal off target damage occurred in the trial. At Site 1, in the highest rate of flupropanate treatment (0.298 g a.i. tussock^{-1}), off target damage was observed in a small ring surrounding smaller *S. pyramidalis* tussocks (Figure 2). Site 2 had no off target damaged observed and at the time of assessment, *S. pyramidalis* tussocks were starting to breakdown and desired grasses, broadleaf and legumes species had started to fill in the gaps surrounding the treated plants (Figure 2). Overall, off target damage is minimal when applying flupropanate as a spot application due to a direct stream into the target plant. This allows off target species to remain competitive and reduce the risk of new *S. pyramidalis* plants establishing.

Treatments at both sites were applied at the end of the dry season when *S. pyramidalis* tussocks were dry, not actively growing and had no reproductive stems present. At the time of assessment only the untreated control had produced new reproductive stems. Previous research (W.D. Vogler unpublished data) has shown that applying treatments at the end of the dry season allows flupropanate to be taken up by the plant in the first rainfall event of the next wet season, resulting in plant mortality before seed is produced. Applying flupropanate throughout the wet season, still results in mortality, however seed heads may be produced which adds seeds to the seedbank prior to plant death due to the slow acting nature of flupropanate. By applying flupropanate in the late dry season it ensures that infested areas unable to be accessed during the wet season can be effectively treated.

The current alternative to spot application is spot spraying. Spot spraying is a foliar spray on individual plants to the point of runoff (Bray & Officer, 2007). Both application methods effectively control the target species. However, spot spraying increases the risk of off target damage due to the less precise application technique whilst any off-target effects of the spot application technique are limited to a small ring around the tussock base. This allows adjacent grass species to remain competitive to assist with suppression of new WSG seedling establishment.

Figure 2. Site 1, 5 MAT of 0.298 g a.i. tussock^{-1} (L) Site 2, 5 MAT of 0.2235 g a.i. tussock^{-1} (R).

CONCLUSION

Spot application of flupropanate for control of WSG will have a place in the management of limited/ scattered infestations and hard to access areas. It could also be used in larger dense monocultures however use of this technique in these areas is generally considered impractical. This method of spot application was only trialed on *S. pyramidalis*, but results will be similar for other weedy Sporobolus grasses (WSG).

Flupropanate is primarily a root uptake rain activated herbicide that can be applied in the dry season and become active in the wet season. This allows the control of target species when access to apply herbicides is restricted by weather and road conditions. A minor use permit (PER94351) for treating WSG with flupropanate by spot application has been approved by the Australian Pesticides and Veterinary Medicines Authority (APVMA). The rate on the permit is 0.3 mL of flupropanate in a 5 mL shot per tussock. This permit also includes spot application for *C. polystachios*, *A. gayanus* and *C. setaceus* which extends the methods of control available to land managers for these invasive plants (APVMA, 2024).

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