Improving management of Giant Rat's Tail Grass (GRT) in coastal and subcoastal regions of Central Queensland

A report for Gladstone Regional Council (GRC)

Wayne Vogler and Clare Warren

Department of Agriculture and Fisheries

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Contact details
Dr Wayne Vogler
Principal Scientist
Biosecurity Queensland, Department of Agriculture and Fisheries
Tropical Weeds Research Centre
PO Box 976, Charters Towers, QLD 4820
E. Wayne.Vogler@daf.qld.gov.au

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Executive Summary

Gladstone Regional Council (GRC) and Biosecurity Queensland joined in a collaborative project to further expand knowledge and practice of giant rat's tail grass (GRT) management in the Gladstone region. GRT causes significant economic and environmental impacts within QLD. Several research trials were developed and conducted within the Gladstone region to expand the control options available for the effective management of GRT across different land types and situations (including grazing, peri-urban and forestry). Effectively managing GRT does not mean eradication but that the negative impact of GRT on production, business operations and amenity is low and that the cost of ongoing management is able to be met by landholders. As part of the project, extension activities were conducted to keep landholders up to date with the progress of the trials and to upskill local government officers.

The research trials that were conducted are as follows:

- Fertiliser application research to improve GRT forage quality.
- Effect of fire, vegetative cover and ash on flupropanate efficacy and persistence.
- Determining the appropriate timing for flupropanate application and flupropanate application rate for dense and scattered infestations.
- Grass species tolerance to flupropanate and other herbicides.
- Effect of spray volume on flupropanate efficacy.
- Integrating pasture establishment with giant rat's tail grass control.
- Flupropanate spot application for GRT control.

Key Findings

- Fertiliser can aid in initial pasture establishment to increase competition from competitive species to minimise GRT populations and can be used to improve GRT fodder quality by making it more palatable to livestock. The application of fertiliser can increase crude protein and digestibility levels in new GRT growth, thereby making it more acceptable to cattle and improving utilisation and potential cattle weight gains. The economics of fertiliser application as part of a GRT management remain unclear and will need to be determined by individual landholders prior to application.
- Fire can be beneficial for control GRT, when it is used effectively as part of an integrated management program to assist in pasture establishment or when followed by herbicide application.
- High levels of flupropanate efficacy were obtained when flupropanate was applied straight after a fire, directly into the ash. In contrast, burning prior to significant rainfall following flupropanate application resulted in poor efficacy with the herbicide being consumed by the fire or made inactive by the heat exposure. The ash from grass fires did not adversely affect flupropanate efficacy.
- Flupropanate can be applied at any time of the year to control GRT while achieving high efficacy.
- Rhodes grass (*Chloris gayana*), Signal grass (*Urochloa decumbens*), Black spear grass (*Heteropogon contortus*), Indian couch (*Bothriochloa pertusa*), Forest blue grass (*Bothriochloa bladhii*), Spring grass (*Eriochloa sp*.), Thatch grass (*Hyparrhenia rufa*), Wynn Cassia (*Chamaecrista rotundifolia* cv Wynn) and Stylo species (*Stylosanthes spp*.) are tolerant of flupropanate when applied according to label instructions.

- Spray volumes from 100L/ha to 500L/ha during boom spray application of flupropanate does not affect flupropanate efficacy.
- Dense GRT is able to be changed to a Signal grass dominant pasture within 4 years by using a combination of slashing, flupropanate, seed and fertiliser application and removing grazing pressure.
- Spot application using 0.2 – 0.3 ml of flupropanate/tussock is a useful technique to control isolated and scattered GRT plants.

Introduction

Giant rat's tail grasses *(Sporobolus pyramidalis and Sporobolus natalensis)* (GRT) are exotic, unpalatable high biomass grasses which are now estimated to infest more than 450 000ha of grazing land in eastern Queensland and New South Wales. GRT is most common in areas where the average annual rainfall is above 700 mm but will grow in areas where the average annual rainfall is as low as 500 mm. Significant infestations occur in the Kilcoy, Sunshine Coast, Gympie, Bundaberg, Gladstone, Rockhampton, Mackay and Mareeba areas and parts of inland Central Queensland.

GRT is a category 3 restricted invasive plant under the *Biosecurity Act 2014*. Meaning, GRT must not be given away, sold or released into the environment. All reasonable and practical measures to minimise the biosecurity risks associated with dealing with GRT should be taken as part of the general biosecurity obligation (GBO). GRT is a problem for a range of land managers including graziers, Queensland Parks and Wildlife Service, utilities and local government. Dense GRT infestations can effectively make beef cattle production unviable, increase fire hazard for all land managers and reduce biodiversity due to the exclusion of other herbaceous and grass plants and the formation of monocultures.

The management of GRT is made more difficult due to the limited range of herbicides available to selectively control this weedy grass in a grassy natural environment of production pasture. Herbicide alone will not provide the most efficacious and economic long term control of GRT. Integrated land management using a range of techniques such as herbicide application, pasture management to maintain soil cover and competitiveness and implementation of weed seed hygiene practices are required to effectively deal with GRT on a long-term basis.

There has been a significant amount of research and extension work done to improve the knowledge and management of GRT since the mid 1990's with at least three Meat and Livestock co-funded projects on the ecology, management and potential biological control of this weed. The findings of this research have been published in two editions of a management manual the last of which was completed in 2007 (Bray & Officer, 2007). This management manual is currently being updated and will include the research finding from this project. Current research (other than that in this project) has focused on determining the effectiveness of a crown rot as a biological control agent for GRT and the use of fertilisers to manipulate GRT palatability and improve the competitiveness of sown pastures as a way of making cattle grazing profitable whilst reducing the presence of GRT.

Project Objectives

This project aims to fill knowledge gaps and refine a range of management options that will help manage GRT across different land types and situations including grazing, peri-urban and forestry. Outcomes of this research will help inform effective management of GRT and complement current GRT management programs. Research outcomes will be communicated through extension activities such as field days, training workshops, print material and other relevant mediums.

Specifically, the project aims to:

1. Determine the appropriate timing and application rate of flupropanate for the control of GRT.
2. Determine the role of fertilisers in manipulating GRT palatability. How much fertiliser is needed to make GRT more palatable?
3. Determine the effect of flupropanate and other herbicides on a range of native and sown grass species on a range of soil types.
4. Determine if burning pasture prior to flupropanate application improves flupropanate efficacy and whether the ash from such fires has any significant effect on herbicide efficacy.
5. Document the findings of the project in an appropriate format.

Trial Site Details

Four sites within the Gladstone region were used to conduct research trials and extension activities during the project. Site details are outlined below.

- Site 1: A private grazing property on Calliope River Road, backing onto the Calliope River. The vegetation was native woodland with cleared areas of predominantly native pasture infested with scattered GRT clumps and individual plants. An electric fence was used to exclude cattle from the area for the duration of the trial.
- Site 2: A privately owned grazing property off Tableland Road, at Mt Tom south east of Miriam Vale. The vegetation was a cleared grass pasture consisting almost entirely of GRT. Cattle were removed from the paddock for the duration of the trial. This site was ideally located for field day and demonstration purposes and assisted in meeting the extension aspects of the project.
- Site 3: A privately owned grazing property off Tableland Road, at Mt Tom south east of Miriam Vale. The vegetation was a cleared grass pasture consisting predominately of GRT with some native and sown pasture species present. Cattle were removed from the paddock for the duration of the trial.
- Site 4: This site was located on a privately owned grazing property on Clifton Road, Diglum, south west of Calliope. The vegetation was native woodland with cleared areas of predominantly native pasture infested with scattered GRT clumps and individual plants. Cattle were present within the trial site for the duration of the project.

Fertiliser application research to improve GRT forage quality

Fertiliser application can be used as a tool to improve GRT management outcomes. The addition of fertiliser as part of routine management of sown pastures acts to improve the amount of forage produced and maintain a competitive pasture sward to reduce the risk of widespread GRT establishment. Previous research conducted by the Department of Agriculture and Fisheries found that while fertiliser application is beneficial for sown pasture species it also improved the forage quality of GRT encouraging cattle to graze GRT tussocks which enhanced GRT management outcomes in sown pasture systems. This trial tried to refine the fertiliser application rates to identify the minimum application rate needed to change the forage quality (digestibility and protein content) to a more acceptable level for livestock production.

Method:

This replicated trial with seven treatments was conducted on Site 2. All plots were slashed and plant residue removed prior to treatment application to allow more accurate assessment of treatment effects. Soil samples were taken before treatment to determine beginning level of nutrients in the soil and indicated that the soils at this site were deficient in available nutrients for plants growth with plant available Nitrogen (N) as nitrate and Phosphorus (P) being 4.2 mg/kg and 8.6 mg/kg respectively while soil pH was 5.5.

The fertilisers used in this trial is Diammonium Phosphate (DAP) (18% N and 20% P) and Urea (46% N) were applied as a single application in January 2020 using a lawn fertiliser spreader. A base rate of DAP was applied to all fertiliser treated plots followed by various rates as once a sufficient level of available P is reached available N is a main determinant of grass growth.

Actual application rates were higher than planned due to an application error but would still provide valuable information as to the effect of N and P on GRT yield and forage quality. Treatments were as follows:

1. Control (untreated)
2. DAP (90 kg/ha N, 100 kg/ha P)
3. DAP (90 kg/ha N, 100 kg/ha P) + Urea (40 kg/ha N)
4. DAP (90 kg/ha N, 100 kg/ha P) + Urea (80 kg/ha N)
5. DAP (90 kg/ha N, 100 kg/ha P) + Urea (120 kg/ha N)
6. DAP (90 kg/ha N, 100 kg/ha P) + Urea (160 kg/ha N)
7. DAP (90 kg/ha N, 100 kg/ha P) + Urea (200 kg/ha N)

Grass samples were collected from the central square metre of each plot at each sampling time. GRT leaves were collected from each plot prior to treatment application and at 5 weeks after treatment (WAT) application. At 9 WAT GRT leaves and stems were collected and processed separately. After collection, all samples were dried at 60°C for two days and then sent to the University of Queensland for forage quality analysis. At 9 WAT, dry matter yield was determined in each plot by cutting all of the GRT to two cm high in one 50 cm by 50 cm quadrat placed in the centre of each plot. The cut GRT was then bagged, dried at 80°C for two days and weighed to determine total dry matter yield in each plot.

Results:

At 5 WAT and 9 WAT GRT plant development was pre stem elongation (green and leafy) and at the point of seed head emergence, respectively. At 9 WAT mean dry matter yield of the unfertilised control treatment was significantly different to all fertilised treatments with more than 4500 kg/ha less dry matter yield than the mean yield in any fertilised treatment. Fertilised treatments while showing some variability where not significantly different and ranged from 10,272 to 13,943 kg/ha (Table 1).

Table 1. Mean dry matter yield of GRT in fertilised treatments 9 WAT.

Treatment #	Treatment	Yield (Kg/ha)
1	Untreated Control	5,685
2	DAP (90kg/ha of N)	10,800
3	DAP (90kg/ha of N) + Urea (40kg/ha of N)	10,723
4	DAP (90kg/ha of N) + Urea (80kg/ha of N)	10,741
5	DAP (90kg/ha of N) + Urea (120kg/ha of N)	10,272
6	DAP (90kg/ha of N) + Urea (160kg/ha of N)	13,943
7	DAP (90kg/ha of N) + Urea (200kg/ha of N)	11,548

All fertiliser treatments increased the digestibility of the fresh GRT leaves at 5 WAT compared to pre-treatment levels with digestibility increasing 8 to 15% to a maximum of 59% depending on fertiliser treatment (Figure 1). The digestibility of the untreated control also increased 5% mainly due to the leaves being young and fresh compared to the older more mature leaves sampled prior to treatment application. At 9 WAT the digestibility levels had dropped due to the GRT being a later stage of maturity but remained above pre-treatment levels except for the digestibility of the untreated control which fell to near pre-treatment levels (Figure 1) once the GRT become reproductive. The largest increases in digestibility occurred up to the fertiliser application rate of Treatment 3 (Table 1 and Figure 1) with smaller increases as the fertiliser application rate increased from Treatments 3 to 7 indicating that the gains of adding extra fertiliser will need to be carefully considered against the cost of extra fertiliser.

The general trend with all fertiliser treatments at 5 WAT was that the more fertiliser applied the greater the crude protein and digestibility of GRT plant material. There was less of a difference in crude protein and digestibility between fertiliser application rates as rates of fertiliser increased. As expected, the GRT stems that were collected at 9 WAT had lower mean crude protein and digestibility compared to the leaf samples with differences in crude protein and digestibility between treatments not significant. The visual effects of fertiliser application to GRT can be seen in Figure 3.

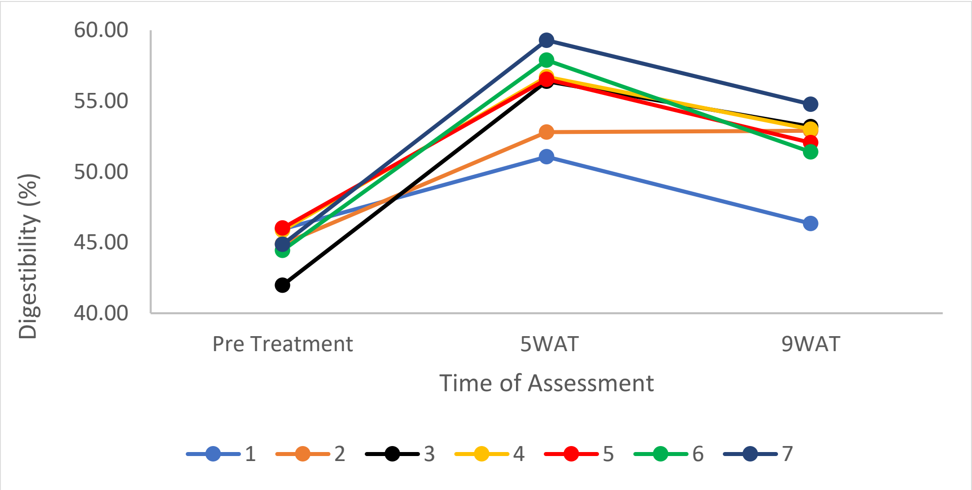

Figure 1. Mean digestibility (%) of GRT over time for each treatment. The numbers in the legend refer to each treatment (see Method or Table 1).

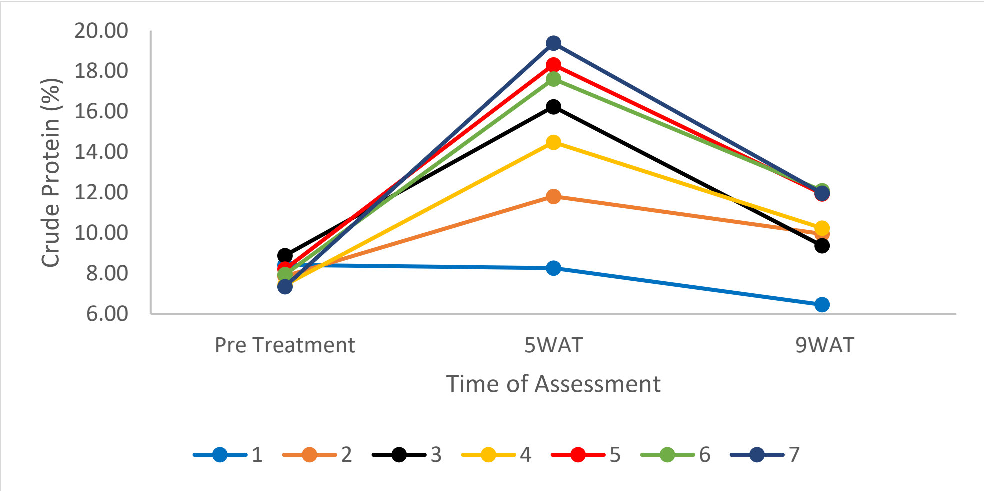

Figure 2. Mean crude protein (%) of GRT over time for each treatment. The numbers in the legend refer to each treatment (see Method or Table 1).

As feed digestibility increases a greater proportion of the feed eaten will be of use to the animal (Moran 2005). For example, the 51% digestibility of unfertilised GRT at 5 WAT means that of a GRT stand with a dry matter yield of 4000 kg/ha only 51% (2040 kg/ha) of the GRT stand if it was all eaten is of actual use to the animal. The rest is roughage which is passes through the animal in the manure. If the digestibility of the same GRT stand was increased by fertiliser application to 56% at 5 WAT then 2240 kg/ha of that GRT is useable by cattle which is an increase of almost 10%. In practical terms this means there is more energy in each bite of GRT meaning more available energy for potential weight gain.

As crude protein increases above maintenance levels for cattle (approximately 7%) more protein becomes available for animal growth (Moore et al 2021). Unfertilised GRT had a crude protein level of 8% in fresh growth 5 WAT (Figure 2) which is a maintenance level for cattle compared to 16% crude protein in fresh GRT leaves at 5 WAT for fertiliser application levels in Treatment 3 (Figure 3 and Table 1). This indicates that fertiliser application can increase crude protein to level that are sufficient for animal growth provided enough energy is available (Moore et al 2021).

The results showed that for fertiliser application rates higher than those in Treatment 3 (130 kg N/ha + 100 kg P/ha) the benefit gained from applying more fertiliser in terms of increased digestibility and protein is reduced and therefore will have less of an economic benefit (Figures 1 and 2). To ensure cattle production benefits from fertiliser application are maximised, GRT needs to be kept short with mostly fresh growth being available to cattle. This is because as GRT matures it shifts focus to reproduction and therefore the protein and digestibility decrease to much lower levels.

While the results of this study indicate that fertiliser application can significantly improve GRT forage quality the authors of this report do not make or infer any fertiliser application rate recommendations or any economic analysis associated with fertiliser application on GRT. The economics of fertiliser application to improve forage quality of GRT and any associated recommended application rate are outside the scope of this project with decisions about whether to apply fertiliser and how much to apply entirely the responsibility of the landholder and specialist advisers.

Figure 3. The visual difference between the untreated control (light green) and a treatment of DAP (90kg/ha of N) + Urea (120kg/ha of N) (dark green) at 5 WAT.

Treatments for a second trial were applied at Site 4. Unfortunately, due to a poor wet season resulting in very limited GRT growth, no results were able to be collected. Additional trials are currently being conducted by the University of Queensland to increase knowledge about the effect of fertiliser application on GRT forage quality. For more detailed information on fertiliser application on grass pastures consultation with a pasture agronomist or beef extension officer is recommended.

Effect of fire, vegetative cover and ash on flupropanate efficacy and persistence.

There has been some concern that too much vegetation cover, unplanned fires or the grass ash from planned burns in GRT areas could reduce the efficacy of flupropanate. This has sometimes led to the practice of pre-burning GRT infested areas to remove vegetative matter and then waiting for 25-50 mm of rain to disperse the grass ash prior to flupropanate application. The effect of vegetation cover, unplanned fires or the grass ash on flupropanate herbicide efficacy has not been sufficiently studied to determine the benefit or otherwise of vegetation removal by fire prior to flupropanate application. This trial was conducted at Site 2 and investigated the effects of fire, vegetative cover and ash on the efficacy and persistence of liquid and granular flupropanate applied to dense stands of GRT.

Method:

This trial included 13 treatments with two replicates of each treatment. Both liquid and granular flupropanate was applied with different combinations of burning and simulated rainfall against an untreated control.

Treatments were applied during August 2018 and were as follows:

1. Untreated control
2. Burn only
3. Flupropanate (liquid) applied, no burning (with vegetative cover)
4. Flupropanate (granular) applied, no burning (with vegetative cover)
5. Flupropanate (liquid) applied, then burnt prior to rainfall
6. Flupropanate (granular) applied, then burnt prior to rainfall
7. Flupropanate (liquid) applied, rainfall, then burnt
8. Flupropanate (granular) applied, rainfall, then burnt
9. Burnt then flupropanate (liquid) applied prior to rainfall
10. Burnt then flupropanate (granular) applied prior to rainfall
11. Burnt, rainfall, then flupropanate (liquid) applied
12. Burnt, rainfall, then flupropanate (granular) applied
13. Slash vegetative matter, apply flupropanate liquid.

Liquid flupropanate (Taskforce® (745 g/L flupropanate)) was applied at a rate of 2 L/ha without a wetter using a boom spray at a spray volume of 200 L/ha. Granular flupropanate (GP flupropanate (86.8 g/kg flupropanate)) was applied at a rate of 15 kg/ha using a Scotts® Easy Hand-Held Broadcast Spreader calibrated in accordance with instructions from Granular Products. All plot fires were done as slow back burns. The simulated rainfall treatment was applied by hand watering relevant plots with each plot receiving 400 L of water which is equivalent of 25 mm of rain. The cut vegetative matter from the slash treatment were left within the plot and the flupropanate was applied over the top. Within a few days of the establishment of the trial the site was burnt out by a wildfire resulting in the loss of the control treatment (untreated plots) which had minimal impacts on the results. Weather conditions were measured at several times during the fire component of the trial with fuel load and fuel moisture determined by cutting and bagging the vegetation to a height of 2 cm in three 50 cm by 50 cm quadrats randomly placed across the trial area. The sampled vegetation was dried at 80°C in a drying oven for two days to remove any moisture and dry matter kg/ha and moisture content were calculated. Weather and fuel conditions are presented in Table 2.

Table 2. Weather conditions, fuel load and moisture during the fire component of the trial.

Parameter	Mean (Range)
Temperature (°C)	22.4 (20.4-23.8)
Humidity (%)	19.5 (19-20)
Wind Speed (km/hr)	8.6 (3.4-18.3)
Fuel Load (kg/ha dry matter)	5,666 (4,061-6,609)
Fuel Moisture (%)	26.8 (26-27.5)

Assessments were completed at 5 and 8 months after treatment (MAT) in January and April 2019. Two 1 m^2 quadrats were assessed for each plot. Within each quadrat the following was counted and recorded:

- Number of alive GRT plants
- Number of dead GRT plants
- Number of GRT plants with seed heads
- Number of GRT seed heads per quadrat
- Number of GRT seedlings per quadrat

Results:

The results showed burning on its own is not an effective control measure as no mortality was recorded and seed production was promoted. The burn flupropanate (liquid) and burn rain flupropanate (liquid) treatments had the greatest GRT mortality with GRT mortalities > 97% and no seed head production (Figure 4). This result shows that liquid flupropanate has good efficacy when applied straight after a grass fire with little adverse impacts of ash when applied either prior or post rain. The equivalent granular flupropanate treatments resulted in GRT mortalities of > 65% and had some seed head production. It is unclear why the granular flupropanate efficacy for these treatments was lower than that of liquid flupropanate.

The flupropanate (liquid or granular) burn treatment resulted in < 5% GRT mortality, due to the herbicide being destroyed by the fire as it had not been moved to the soil by rainfall prior to burning. The risk of this occurring needs to be considered prior to flupropanate application particularly when applying flupropanate in the seasonally dry part of the year. Rain must occur after flupropanate application to move the flupropanate into the soil where it is protected from any subsequent fire event.. The slash flupropanate (liquid) treatment had a mean mortality of 96% with no seed head production indicating that high vegetation loads at the time of flupropanate application have little negative impact on flupropanate efficacy (Figure 4). These are early results from a single trial on a single soil type and should be taken as such until more trial work can be completed to confirm these results.

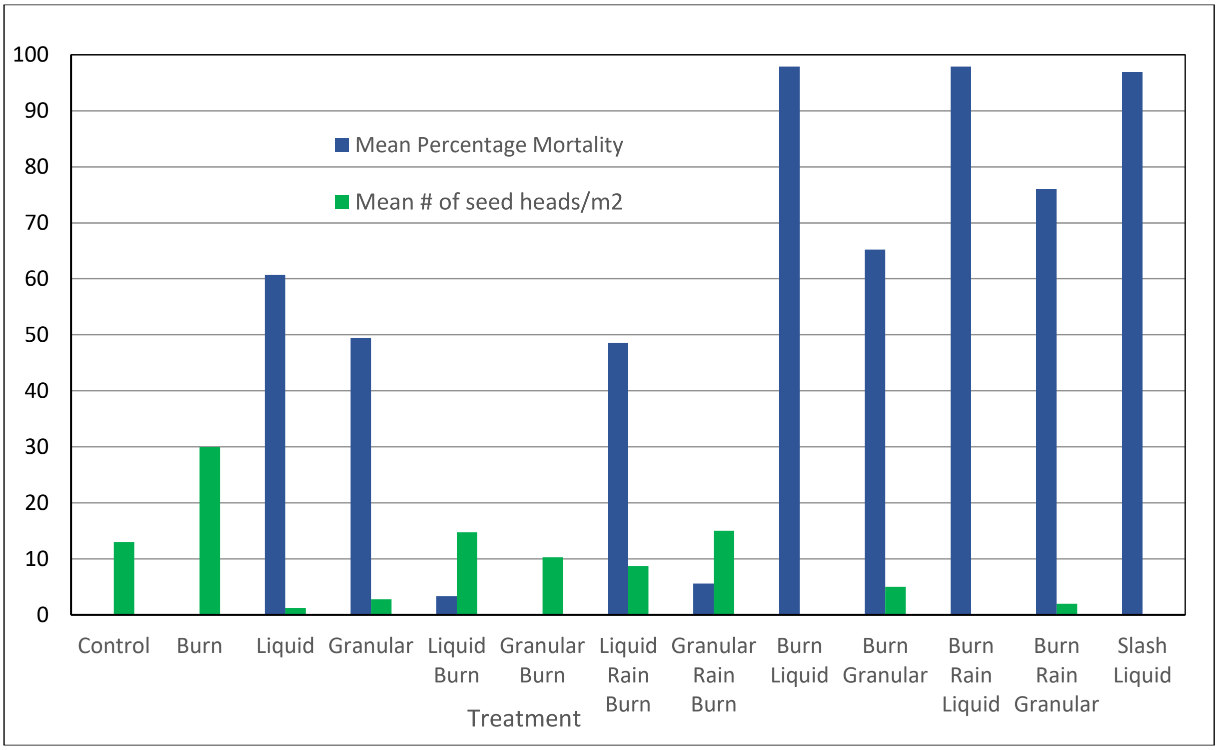

Figure 4. The effect of fire, ash and rain on flupropanate efficacy, 8 MAT.

A second fire trial was established in October 2021 on the same property with six of the most relevant original treatments and no replicates. This non-replicated trial was to confirm results from the original trial and act as a demonstration for a field day held on the property in March 2021. Visual assessments took place 19 WAT and showed comparable results to the original trial (Figures 5, 6 and 7). Efficacy assessments did not take place due to the property changing owners prior to this being able to be done.

Figure 5. Effect of the untreated control (L) and liquid flupropanate (R), on GRT 19 WAT.

Figure 6. Effect of slash, liquid flupropanate (L) and liquid flupropanate, burn (R), on GRT 19 WAT.

Figure 7. Effect of liquid flupropanate, rain (15 ml), burn (L) and burn, liquid flupropanate (R), on GRT 19 WAT.

Determining the appropriate timing for flupropanate application and application rate for dense and scattered infestations.

There is considerable debate about the most appropriate time of year to apply flupropanate for effective GRT control. Determining the seasonal timing of flupropanate application to ensure the most reliable result on GRT is critical to successful GRT management. This trial will determine at what time throughout the year (pre-growing, mid-growing or late-growing season) flupropanate should be applied to provide the best control of GRT.

Methods:

This trial consisted of three main plot and three sub-plot treatments with four replicates of each treatment. The pre-growing season treatment was applied in November 2019, the mid-growing season treatment was applied in February 2020 and the late growing season treatment was delayed till later than desirable due to COVID-19 and applied in June 2020. Liquid flupropanate was applied without a wetter using a boom spray with a spray volume of 200 L/ha.

Main Plot Treatments:

1. Untreated control
2. Flupropanate (liquid) 1.5 L/ha
3. Flupropanate (liquid) 2 L/ha

Sub Plot Treatments:

1. Pre-growing season
2. Mid-growing season
3. Late growing season

Two assessments were completed to measure the efficacy of liquid flupropanate. In June 2020, the pre-growing season and mid growing season treatments had an initial assessment (7 and 4 MAT respectively). Four 1 m^2 quadrats were assessed within each plot. Each GRT plant within each quadrat was given a health rating between 1-4, where: 1 = appeared dead (0% green), 2 = unhealthy (>0 – 10% green), 3 = relatively healthy (>10-50% green) and 4 = healthy (>50% to 100% green). The number of GRT plants with seed heads and other species present was also recorded. In April 2021 (after the next growing season due to COVID-19 travel restrictions), all treatments were assessed (pre-growing season 17 MAT, mid-growing season 14 MAT and late growing season 10 MAT). GRT plant density was recorded in four 1 m^2 quadrats within each plot. Mortality was not recorded in this assessment due to the difficulty in finding dead tussocks which had decomposed since treatment application. Other species present in the plots was also recorded.

Results:

In the June 2020 assessments, the pre-growing season treatments had a mean mortality of 90.5% for 2 L/ha flupropanate and 68.67% for 1.5 L/ha flupropanate. It was noted that the surviving plants for both application rates only had one or two green leaves. The mortality for the mid growing treatments for both rates of flupropanate was <5.2% (Table 3). However, the chemical effect was evident with plants yellowing with stunted growth and reduced seed head production compared to the untreated control (Figure 8).

In the April 2021 assessments, the untreated control plots had a significantly greater density of live GRT plants compared to the flupropanate treatments for all application times. The pre- and mid-growing season flupropanate treatments had reduced number of alive GRT tussocks compared to the previous year. The late growing season treatments had comparable results to both the pre- and mid-growing season treatments (Table 3). A wide variety of other grass species were growing in the plots including Rhode's grass, signal grass, black spear grass and forest bluegrass.

This trial clearly indicates that flupropanate can be successfully applied at most times of the year without significant reductions in efficacy. When applied pre-growing season there is an added benefit of almost no seed production in the growing season following herbicide application. The later into the growing season flupropanate is applied the more seed will be produced and when application is done towards the end of the growing season it may take until after the following growing season to clearly see significant GRT mortality.

Table 3. The impact of flupropanate on GRT when applied at different application rates and times.

Main Treatment	Sub Treatment	Mean GRT mortality (%)	Mean GRT plants with seed heads (%)	Mean number of alive GRT plants/ m^2	
		June 2020	June 2020	June 2020	April 2021
Control	Pre-growing	0.65	77.27	9.56	6.63
	Mid-growing	2.60	77.92	9.38	6.63
	Late growing	n/a	n/a	n/a	6.69
Flupropanate 1.5 L/ha	Pre-growing	68.67	3.33	2.94	1.13
	Mid-growing	4.67	9.33	8.94	0.69
	Late growing	n/a	n/a	n/a	0.38
Flupropanate 2 L/ha	Pre-growing	90.57	0.00	0.94	0.13
	Mid-growing	5.16	7.10	9.19	0.19
	Late growing	n/a	n/a	n/a	0

Figure 8. GRT treated with flupropanate at 2 L/ha when applied as a pre-growing season treatment (L) and as a mid-growing season (R) in June 2020 at 7 and 4 MAT respectively.

Grass species tolerance to flupropanate and other herbicides.

The tolerance of individual grass species to flupropanate is not well defined. Little information from trial work is available regarding the impact flupropanate has on native or introduced grasses which are required to compete against GRT and assist with GRT suppression. This trial included a range of herbicides as a single application rate to determine if there is an effect of the herbicides on the species present in the trial.

Method:

This trial consisted of 6 herbicide treatments with 3 replicates of each.

Treatments were:

1. Untreated control
2. GP flupropanate (86.9 g/kg flupropanate) – 15 kg/ha (applied Nov 2018)
3. Taskforce® (745 g/L flupropanate) - 2 L/ha (applied Nov 2018 and Feb 2020)
4. Glyphosate 360 (360 g/L glyphosate) - 2 L/ha (applied Feb 2020)
5. Mako® (750 g/kg sulfometuron methyl) - 400 g/ha (applied Feb 2020)
6. Verdict® (520 g/L haloxyfop) - 0.8 L/ha (applied Feb 2020)

All liquid herbicide treatments were applied using a boom spray and granular flupropanate was applied using Scott's® Easy Hand-Held Broadcast Spreader. A wetter (Uptake® spraying oil 50 ml/10 L) was added for glyphosate, sulfometuron and haloxyfop treatments. Liquid and granular flupropanate were applied in November 2018 however the other (foliar) treatments were not applied at this time due to insufficient rainfall and poor plant condition for foliar herbicide application. All treatments apart from the granular flupropanate were applied in February 2020. This included a re-application of the liquid flupropanate treatment.

Assessments of the plots treated with liquid and granular in November 2018 were conducted in August 2019. Twenty GRT plants within each plot 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% to 100% green). Other species that were in the plot with seed heads present were also given a health rating, up to 20 plants for each species were rated per plot. Assessments for all treatments were conducted in June 2020. This assessment was only a visual assessment, focusing on the effects of the herbicide treatments on GRT and competing pasture grasses.

A pre-treatment survey of the trial area identified that GRT, thatch grass (*Hyparrhenia rufa*), forest blue grass (*Bothriochloa bladhii*), black spear grass (*Heteropogon contortus*) and Rhodes grass (*Chloris gayana*) were present.

Results:

In August 2019, the GRT in the liquid and granular flupropanate treated plots had a mean mortality of 93% or higher. Thatch grass, forest blue grass, Rhode's grass and black spear grass were found actively growing within these plots (Table 4).

Table 4. The impact of flupropanate on GRT and other pasture grasses, 9 MAT.

Treatments	Species	Mean Health Rating
Control	GRT	3
	Thatch grass	3
	Forest blue grass	3
	Rhode's grass	3
	Black spear grass	3
Liquid flupropanate (2 L/ha)	GRT	1
	Thatch grass	3
	Forest blue grass	2
	Rhode's grass	3
	Black spear grass	3
Granular flupropanate (15 kg/ha)	GRT	1.13
	Thatch grass	3
	Forest blue grass	3
	Rhode's grass	n/a*
	Black spear grass	3

*Rhodes grass in the 15 kg/ha GP flupropanate treatment was not visible at 9 MAT.

The visual assessments that were undertaken in June 2020 observed that both the liquid and granular flupropanate treated plots had high mortality of GRT with no established GRT plants present. Desirable pasture grasses; Rhode's grass, black spear grass and forest blue grass were healthy and reproductive. In Glyphosate treated plots GRT, black spear grass, forest blue grass, thatch grass and broadleaf herbaceous plants were severely damaged. The majority of the Rhode's grass in the glyphosate treated plots was actively growing and reproductive with many seed heads present (Figure 9). Sulfometuron and haloxyfop treated plots had severely damaged GRT plants with stunted growth and minimal seed head production. In the sulfometuron plots black spear grass, forest blue grass and stylo was stunted but still reproductive. In the haloxyfop treated plots all grasses apart from GRT were dead. GRT was severely damaged but alive and beginning to recover. Stylo and other broad leaf herbaceous plants appeared unaffected by the haloxyfop and covered the majority of the plot (Figure 10). Unfortunately, although sulfometuron and haloxyfop caused severe damage to GRT, plant mortality was low indicating they are not suitable alternate herbicides for the management of GRT.

Figure 9. Glyphosate treated plots showing healthy Rhode's grass, 4 MAT (L). Liquid flupropanate treated plots showing no GRT present and minimal damage to other plants species, 4 MAT (R).

Figure 10. Sulfometuron treated plots showing stunted grasses and stylo, all producing seed, 4 MAT (L). Haloxyfop treated plots showing stylo and other broad leaf herbaceous plants not affected and severely damaged GRT tussocks, 4 MAT (R).

Effect of spray volume on flupropanate efficacy.

Anecdotal evidence suggests that the use of higher spray volumes when applying liquid flupropanate to GRT can increase flupropanate efficacy. This trial aims to determine if the spray volume effects flupropanate efficacy when applied to GRT.

Method:

The trial was undertaken twice in two different locations (site 1 and 3). Both trials were identical and had 6 treatments with 4 replicates of each. Liquid flupropanate (Tussock™ Herbicide (745 g/L flupropanate) was applied at 2 L/ha using a boom spray at different spray volumes, without a wetter. Treatment application for Site 1 occurred in November 2018 and Site 3 occurred in November 2019.

The spray volume treatments applied were:

1. Untreated control
2. 100 L/ha spray volume
3. 200 L/ha spray volume
4. 300 L/ha spray volume
5. 400 L/ha spray volume
6. 500 L/ha spray volume

Site 1: Assessments were conducted 9 MAT in August 2019. Twenty GRT tussocks in each plot 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% to 100% green). Other species found within the plots at the time of assessment were also recorded.

Site 3: Assessments were conducted 7 MAT in June 2020. Four 1 m^2 quadrats were assessed for each plot. Within each quadrat, up to 10 GRT plants were given a health rating. Out of those 10 plants, the number of plants with seed heads present were recorded. Other species found within the plots at the time of assessment were also recorded.

Results:

Site 1: There was no significant difference between the different spray volumes used to apply flupropanate. The mean mortality of GRT in all flupropanate treatments was 96% or higher, compared to 8.75% mean mortality in the untreated control (Table 3). Other species present in the plots at the time of assessment included forest blue grass, Rhode's grass, black spear grass, Indian couch and thatch grass.

Site 3: This trial confirmed the results at Site 1. GRT plants in all the flupropanate treated plots had a mean mortality between 77% and 93%. No GRT mortality was recorded in the untreated control (Table 5). The GRT plants in the flupropanate treated plots that were still alive were chemically affected with only one or two green leaves remaining. Other species present at the time of assessment include forest blue grass, Rhode's grass, black spear grass and signal grass.

Table 5. The efficacy of flupropanate on GRT when applied at different spray volumes at Sites 1 (9 MAT) and 3 (7 MAT).

	Site 1		Site 3		
Treatment (Spray Volume)	Mean Health Rating	Mean Mortality (%)	Mean Health Rating	Mean Mortality (%)	Tussocks with Seed Heads (%)
100 L/ha	1.0125	98.75	1.069	93.04	0.00
200 L/ha	1.0375	97.5	1.216	79.75	0.00
300 L/ha	1.075	96.25	1.238	77.07	0.64
400 L/ha	1.0125	98.75	1.175	82.24	1.32
500 L/ha	1	100	1.156	84.81	0.63
Control	2.9375	8.75	3.994	0.00	80.56

The effects of the spray volume treatments at Site 3 can be seen in Figures 11 and 12.

Figure 11. Spray volume plots at Site 3, 7MAT. 100 L/ha (L), 200 L/ha (M) and 300 L/ha (R).


Figure 12. Spray volume plots at Site 3, 7 MAT. 400 L/ha (L), 500 L/ha (M) and untreated control (R).

Integrating pasture establishment with giant rat's tail grass control.

Returning dense GRT infestations to productive pasture systems involves more than just applying herbicides. Integration of several control techniques such as herbicide application, seeding and fertiliser application can produce significant change in pasture composition and in particular reduce GRT and improve production in a relatively short time span. Many of these techniques have been trialled previously however there is a clear need to demonstrate an integrated approach to reducing GRT and increasing productive pasture species and productive capacity of improved pasture systems in the Gladstone area. The establishment of a trial/demonstration site provides a focal point for extension activities for landholders to disseminate information, discuss GRT management approaches and demonstrate a range of integrated management options to return dense GRT infestations to productive sown pastures with minimal soil disturbance. Cultivation during the pasture established phase was not done due to the highly erodible nature of the soils.

Method:

This trial was arranged in 3 replicate blocks with each block containing 6 main plot treatments and 4 sub plot treatments within each main plot. The main plot treatments remained flexible depending on the density of GRT and were determined prior to treatment application each year (Table 4). The sub plot treatments within each main plot consisted of an untreated control, initial seed application, initial seed and annual fertiliser application and annual fertiliser application only. The rate and type of fertiliser changed in the fertiliser treatment during the trial from two initial annual applications of Di-Ammonium Phosphate (DAP) (18% N, 20.2% P) followed by two annual applications of Urea (46% N). DAP was chosen as soil testing indicated that available soil Nitrogen and Phosphorus for plant growth was extremely low and would not provide adequate nutrients for high levels of pasture growth. The change to Urea (N only) followed soil testing indicating that there was sufficient residual Phosphorus in the soil for plant growth following the DAP applications. All fertiliser was applied using a quad bike mounted C-DAX broadcast spreader.

The pasture grass used was signal grass (*Urocholoa decumbens*). It was sown at 4 kg/ha with a Scott's Easy Hand-Held Spreader. This treatment was only applied once in the first year and not in the subsequent years. Flupropanate treatments were applied pre-growing season in the latter part of the year while wick wipe treatments were applied when there was sufficient growth in the early growing season. Fertiliser/seed treatments were applied after sufficient rain had been received in the early growing season (January) the following year.

Table 4. Main plot treatments from 2017-2020.

Main Plot Treatment	2017	2018	2019	2020
1	Control (No treatment)	Control (No treatment)	Control (No treatment)	Control (No treatment)
2	Boom spray (flupropanate 1.5 L/ha)	Boom spray (flupropanate 1.5 L/ha)	Spot spray (flupropanate 200 ml/100 L)	Boom spray GRT (flupropanate 1.5 L/ha), spot application of thatch grass (flupropanate 1.2 ml/plant)
3	Slash, boom spray (flupropanate 1.5 L/ha)	n/a	Slash, boom spray (flupropanate 1.5 L/ha)	Spot application of GRT (flupropanate 0.4 ml/plant) and thatch grass (flupropanate 1.2 ml/plant)
4	Slash	Slash	Slash	Slash
5	Wick wipe (Glyphosate 360 1:5)	Boom spray (flupropanate 1.5 L/ha)	Boom spray (flupropanate 1.5 L/ha)	Boom spray GRT (flupropanate 1.5L/ha), spot application of thatch grass (flupropanate 1.2 ml/plant)
6	Slash, wick wipe (Glyphosate 360 1:5)	Wick wipe (Glyphosate 360 1:5)	Boom spray (flupropanate 1.5 L/ha)	Spot application of GRT (flupropanate 0.4 ml/plant) and thatch grass (flupropanate 1.2 ml/plant)
Fertiliser Sub plot treatment	DAP (73.78 kg of N/ha)	DAP (104.16 kg of N/ha)	Urea (122.01 kg of N/ha)	Urea (65 kg of N/ha)

Figure 13. Aerial view of Block 1 in March 2021.

Change in pasture biomass was assessed to measure pasture composition change in response to each treatment. Assessments were done in each sub-plot prior to any treatment application and then annually in June/July each year. Assessments were completed in twenty 50cm x 50 cm quadrats in each sub plot using the BOTANAL method (Tothill et al. 1992). A quadrat is shown in Figure 14. No assessment was done in 2021 after the final treatment application at the end of 2020 due to the property being sold and access denied prior to when assessments could be done.

Figure 14. Assessing pasture composition in a 50 cm by 50 cm quadrat.

Results:

This trial demonstrated that low grazing value GRT monocultures can be changed to high value signal grass dominant pastures within three to four years if a careful management program is followed. The location proved to be very suitable for demonstration site and hub for extension activities in the Miriam Vale area.

The final assessment showed that four treatments involving boom spray application of flupropanate, seeding of signal grass, fertiliser application and follow up herbicide application (either by boom spray or spot application) to kill the GRT regrowth until the signal grass became dominant (Table 4). These treatments (2, 3, 5 and 6) (Table 4) (Figures 15-17) were able to transform pasture from ~90% GRT to >68% Signal Grass within four years. The trial also confirmed that slashing is not an effective management tool on its own, with close to 100% GRT present in the plots after 4 years. Slashing could be used to remove the bulk of the GRT and promote fresh green shoots that could be grazed to provide some production until such time as more intensive control activities could be completed.

Wick wiping did not work as well in this location as it has where strategic grazing could be done as part of the management program. The inability of this trial to include grazing of wick wiped areas meant that the pasture could not be stratified by height which lessened the usefulness of this herbicide application method at this site.

The trial also demonstrated that signal grass seed could be sown and established without soil disturbance as long as space could be made for seedling establishment in the existing pasture by herbicide application. So well did the signal grass establish that in the latter part of the trial signal grass was readily establishing in unseeded plots. Other species that established in the plots once GRT was removed included Indian couch (*Bothriochloa pertusa*), forest bluegrass (*Bothriochloa bladhii*), black spear grass (*Heteropogon contortus*), Wynn Cassia (Chamaecrista rotundifolia cv Wynn) and other legumes and annual broadleaf species.

In trying to adapt the results of this demonstration trial to other sites it is necessary to consider that the result reported here occurred at one site on one soil type. The results may vary somewhat with different soils, pasture species and climate (particularly rainfall), and also where management/production goals are different.

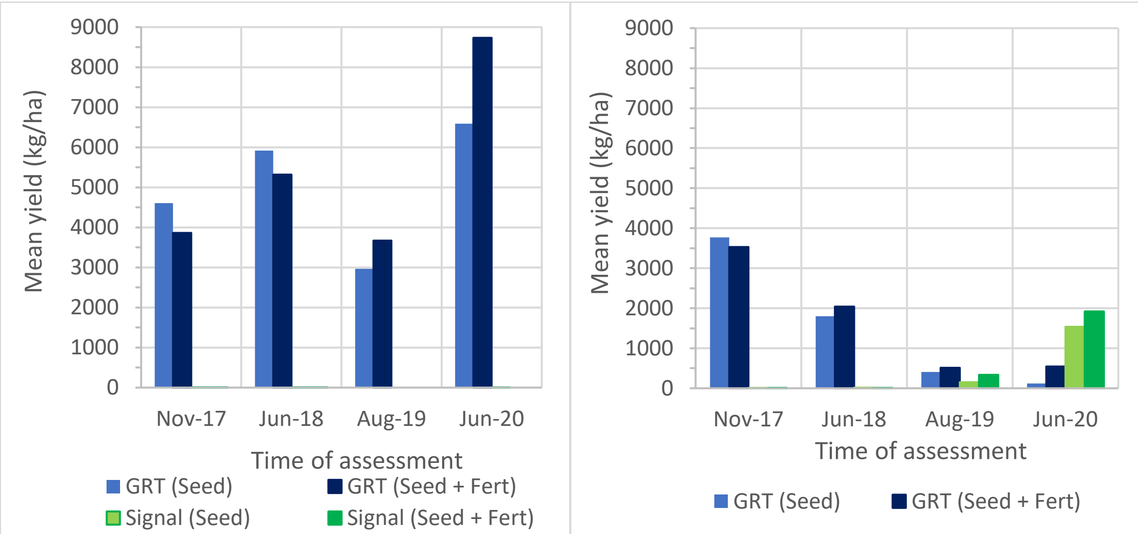

Figure 15. The mean yield of GRT and signal grass for seed only and seed + fertiliser sub treatments within Main Treatments 1 (Control) (left) and 2 (right) at each assessment.

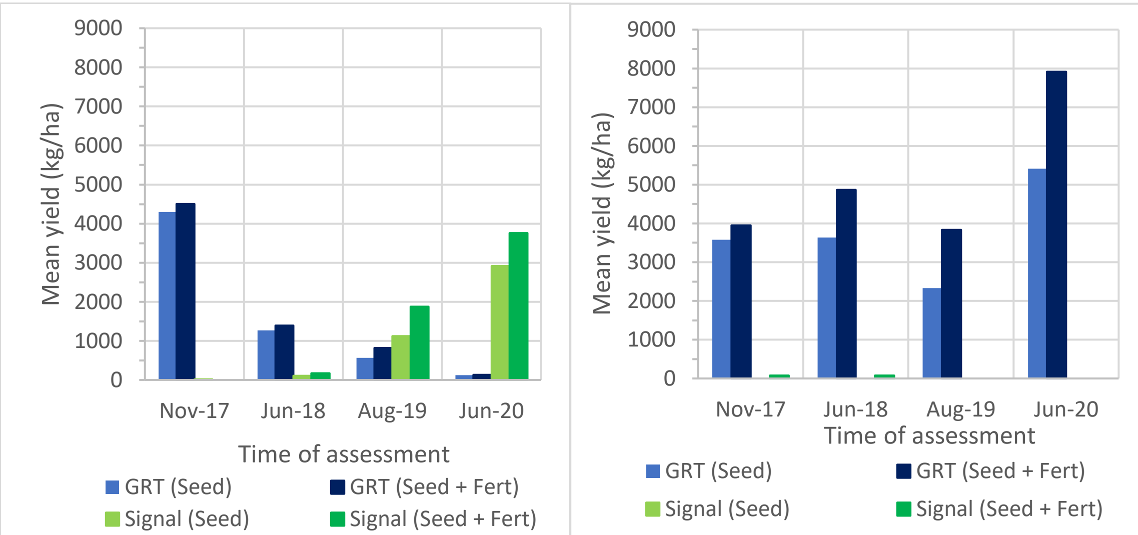

Figure 16. The mean yield of GRT and signal grass for seed only and seed + fertiliser sub treatments within Main Treatments 3 (left) and 4 (right) at each assessment.

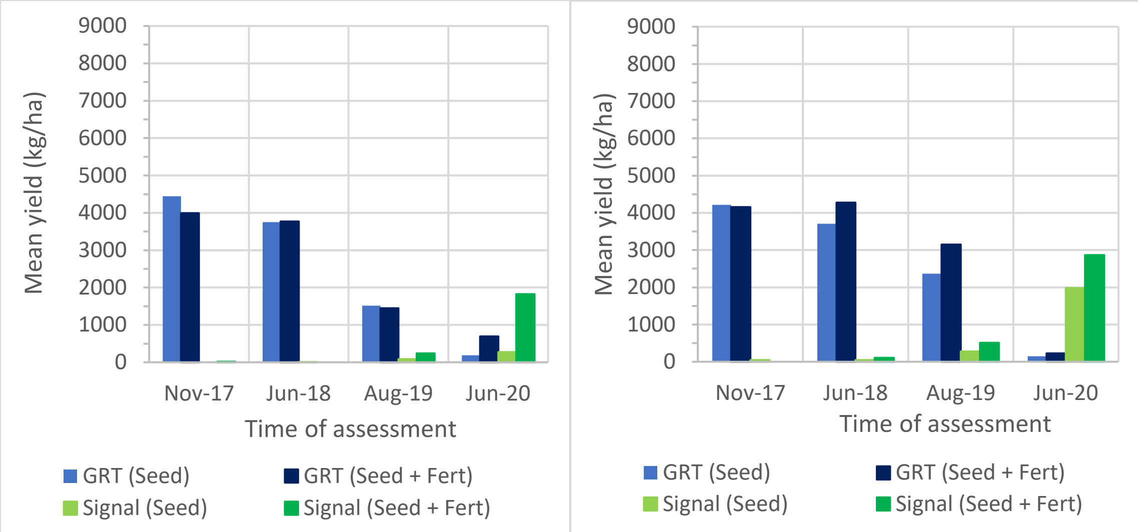

Figure 17. The mean yield of GRT and signal grass for seed and seed + fertiliser sub treatments within Main Treatments 5 (left) and 6 (right) at each assessment.

Flupropanate spot application for GRT control.

Using the fact that flupropanate is almost entirely a root uptake herbicide particularly when applied to dry GRT plants in the non-growing season, a trial was conducted to determine if the application of small amounts of flupropanate directly into the crown (tussock) of GRT the plants would be an effective method for killing individual GRT plants.

In this trial, flupropanate was applied to individual GRT plants using a high concentration, low volume mix applied directly into the base of the tussock. This herbicide application method was previously tested at the Gladstone State Development Area where it was found to be highly effective controlling individual GRT plants. This trial aims to confirm the results from the previous trial and determine if it effective on a fast-draining sandy soil type.

Method:

Liquid flupropanate (Taskforce® (745 g/L flupropanate)) was applied at two rates (0.2 ml and 0.3 ml of liquid flupropanate/tussock) on individual GRT plant. There were four replicate plots of each application rate including an untreated control. Each replicate plot consisted of clumps of GRT containing approximately 15 reproductive GRT plants. Flupropanate treatments were applied with a N.J Phillips® 5 ml Metal Tree Injector (Figure 18) attached to a N.J Phillips® 5 L backpack set to deliver a 4 ml shot via a stream into the centre of the base of the tussock. All visible plants within each plot received one 4 ml shot of each herbicide/water solution, regardless of plant size (e.g. 0.2 ml of herbicide product and 3.8 ml of water). Treated GRT plants varied in size ranging from 5 to 20 cm in basal diameter. GRT seedlings present within the plots were also treated with one 4 ml shot for a group of seedlings. Treatments were applied on the 15th of October 2019.

Figure 18. N.J Phillips® 5 ml Metal Tree Injector.

Mortality assessments occurred 8 MAT in June 2020. Each tussock was given a health rating from 1-4, where: 1 = appeared dead, 2 = re-shooting (one or two leaves only), 3 = both green (> 2 leaves) and dead leaves, 4 = appeared to be healthy. The number of seed heads for each plot was also recorded. Plants in treated plots with no signs of being chemically affected were assumed to be missed and were not included in the results.

Results:

Spot application was found to be highly effective in controlling individual GRT plants with all flupropanate treatments having a mean plant mortality of 98.4% or higher and no seed heads produced (Table 6). The untreated control had no mortality and produced a mean of 7 seed heads per GRT plant. No off-target damage was observed and off target species were growing around treated tussocks at the time of assessment (Figure 19).

Table 6. Impact of spot application of liquid flupropanate at different rates on GRT, 8 MAT.

Treatment	Mean Health Rating	Mean tussock mortality (%)
Untreated Control	3.95	0
0.2 ml of flupropanate/tussock	1	100
0.3 ml of flupropanate/tussock	1.016	98.44

Figure 19. Before treatment, October 2019 (L). 5 MAT, March 2020 (0.2235 g/tussock of flupropanate), off target species surrounding treated tussocks (R).

A non-replicated single rate treatment was undertaken in addition to the main trial. Twenty GRT plants were treated by spot application with liquid flupropanate (Taskforce® (745g/L flupropanate)) at a rate of 0.3 ml/ tussock of flupropanate in a sandy by-wash adjacent to the main channel of a creek. Light rainfall was initially received and no extended heavy downpours occurred during the length of the trial, meaning the by-wash did not run water. At 8 MAT, all but 1 of the treated tussocks had died and no off-target damage was observed with off target species growing around the treated tussocks (Figure 20). Previous boom spray treatments from the owner in these areas was found ineffective due to increased leaching of flupropanate from this soil type resulting in low plant mortality.

Figure 20. Before treatment, GRT in sandy by-wash, October 2019 (L). 5 MAT, Treated tussocks amongst off target species (R).

The application of liquid flupropanate prior to any substantial summer rainfall appears to have resulted in a large amount of the flupropanate being taken up by the plant roots with the first significant rainfall following herbicide application. This is likely to be the reason that treated plants died relatively quickly without producing any seed heads. This also increased the chance for flupropanate to be taken up by the plant before being washed away in substantial rainfall or rapidly breaking down in standing water. The spot application method for applying flupropanate to low density GRT infestations has proved effective for GRT control while providing little off target damage. Follow up control will be needed to treat any missed and new plants.

Key findings

- Fertiliser can aid in initial pasture establishment to increase competition to minimise GRT and can be used to improve GRT fodder quality by making it more palatable to livestock. the application of fertiliser can increase crude protein and digestibility levels in new GRT growth, thereby making it more acceptable to cattle and improving potential cattle weight gains. Once GRT plants become reproductive crude protein and digestibility decrease markedly. The economics of fertiliser application as part of a GRT management remain unclear and will need to be determined by individual landholders prior to application.
- Both mature GRT plants and seedlings are highly tolerant of fire with GRT plants quickly recovering and generally producing large amounts of seed as a result. Fire can be beneficial for control GRT, when it is used effectively as part of an integrated management program to assist in pasture establishment or when followed by herbicide application.
- High levels of flupropanate efficacy were obtained when flupropanate was applied straight after a fire, directly into the ash. In contrast, burning prior to significant rainfall following flupropanate application resulted in poor efficacy with the herbicide being consumed by the fire or made inactive by the heat exposure. The ash from grass fires did not adversely affect flupropanate efficacy.

- Flupropanate can be applied at any time of the year to control GRT while achieving high efficacy.. The main difference observed when applying flupropanate at different times is the number of seed produced while GRT plants are dying. When flupropanate is applied before the growing season, the herbicide is activated in the first rainfall of the season, absorbed by the plant via its roots and generally kills the plant prior to viable seed being produced. Whereas, when flupropanate is applied later in the growing season the GRT plants are already actively growing and continue to produce seed over the 2-3 months it takes for the flupropanate to kill the plant.
- Grass species observed within flupropanate treated plots include Rhodes grass (*Chloris gayana*), Signal grass (*Urochloa decumbens*), Black spear grass (*Heteropogon contortus*), Indian couch (*Bothriochloa pertusa*), Forest blue grass (*Bothriochloa bladhii*), Spring grass (*Eriochloa sp*.) and Thatch grass (*Hyparrhenia rufa*). Broad leaved plants are generally tolerant of flupropanate with the pasture legumes Wynn Cassia (*Chamaecrista rotundifolia* cv Wynn)and Stylo species (*Stylosanthes spp*.) observed growing unaffected by flupropanate. These species are tolerant of flupropanate when applied according to label instructions.
- Spray volumes from 100L/ha to 500L/ha during boom spray application of flupropanate does not make a difference to flupropanate efficacy.
- Dense GRT is able to be changed to a Signal grass dominant pasture within 4 years by using a combination of slashing, flupropanate, seed and fertiliser application and removing grazing pressure. The results from this trial showed that transforming dense GRT stands into productive pastures is possible in a relatively short time period when a considered management plan is in place and the grazing pressure can be managed.
- Spot application is a useful technique to control isolated and scattered plants of GRT, requiring limited equipment enabling treatment in hard to access areas. Australian Pesticides and Veterinary Medicines Authority (APVMA) approval will be sought for spot application on GRT at 0.2 – 0.3 ml of flupropanate/tussock.

Extension activities

A GRT field day was held at Miriam Vale in June 2019. Unfortunately, wet weather caused the field day to be moved to the Miriam Vale Community Hall instead of at the research trial site. Forty-five landholders attended and were presented with and discussed the latest research findings (Figure 21). This was to provide landholders with the latest research findings and to view firsthand progress with the research/demonstration site including the changes in pasture composition in response to a range of treatments. It was also an opportunity for landholders to obtain answers to a myriad of questions about GRT management.

Another field day was held in March 2021 at the Miriam Vale trial site. The day was well received and provided 50+ landholders and other land managers with information about the latest GRT management research findings and an opportunity to view firsthand the changes in pasture composition in response to a range of treatments (Figure 21). Video and photographs were taken on the day for a record of the day and to be used for future engagement activities.

Figure 21. June 2019 presentation at Miriam Vale Community Hall (L) and field day held at trial site in March 2021 (R).

A final GRT forum was held at Miriam Vale in July 2022 to present and discuss the findings of the project, provide a forum to provide answers to questions and to generally wrap up the project. Approximately 60 land managers attended the event to discuss GRT management.

A video is now available on Biosecurity Queensland's YouTube channel about giant rat's tail grass and covers topics including identification, distribution, impacts, methods of spread and prevention.
https://www.youtube.com/watch?v=NEqfeW8cKvs

Two question and answer style videos discussing herbicide use and general GRT management are available on the Gladstone Regional Council YouTube channel. These cover questions that were raised at the March 2021 field day and are available at the following links.
https://www.youtube.com/watch?v=4vHOzCQrLkU
https://www.youtube.com/watch?v=9rx1cH7nZ1I

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