Low-volume high-concentration applications of glyphosate to control gamba grass (*Andropogon gayanus*)

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Summary Gamba grass (*Andropogon gayanus* Kunth.) is a tussock-forming perennial species capable of out-competing other pasture grasses to form dense stands up to 4 m tall. Infestations occur in the Northern Territory, Queensland, and Western Australia, but its current distribution is only a small proportion of its potential range. Once established, gamba grass impacts on the biodiversity and ecosystem function of an area, whilst also imposing a significant fire hazard due to the large biomass that it produces. Controlling invasive grasses amongst other desirable grass species is a challenge, particularly in difficult to access areas where movement of vehicles and equipment is impaired.

To overcome some of these challenges, we undertook a rate response trial on gamba grass to test the efficacy of low-volume high-concentration applications of glyphosate. At a field site near Mt Garnet in North Queensland, a dense stand of gamba grass was slashed in December 2017 and allowed to regrow until April 2018. A randomised complete block experiment comprising seven treatments, three replicates and clusters of 15 gamba grass plants as experimental units was then established. Using a gas operated splatter gun attached to backpack style equipment, six rates of glyphosate (0, 9, 18, 27, 36, 45 and 54 g a.i. L^{-1}) were applied, with each plant directly receiving 4 mL of herbicide mixture per half metre of plant height. An untreated control was also included for comparison. After 3 months, gamba grass showed a strong dose-dependent response ranging from 30% mortality at 9 g a.i. L^{-1} to 100% mortality at rates of 36 g a.i. L^{-1} or higher. Regrowth of any surviving plants was also adversely affected at rates above 9 g a.i. L^{-1} with plants taking longer to reshoot. While promising, a follow up trial has been undertaken on more mature gamba grass plants to determine if similar results can be achieved.

Keywords Herbicide, invasive grasses, splatter gun, weed control.

INTRODUCTION

Gamba grass is native to the tropical and sub-tropical savannas of Africa (Biosecurity Queensland, 2016). Infestations occur in the Northern Territory, Queensland and Western Australia, but its current distribution is only a small proportion of its potential range (e.g. Setterfield *et al.* 2014, Csurhes & Hannan-Jones 2016,). Once established, gamba grass negatively impacts on the biodiversity and ecosystem function of an area, whilst also imposing a significant fire hazard due to the large biomass it produces (Rossiter-Rachor *et al.* 2009, Setterfield *et al.* 2014).

Reducing gamba grass populations is problematic as it is well adapted to the northern wet dry tropics, is a prolific producer of wind dispersed seeds and responds well to periodic burning (Rossiter *et al.* 2003, Bebawi *et al.* 2018). It is highly competitive due to its rapid growth, high biomass and its soil nitrogen harvesting process which limits nitrogen availability (e.g. Setterfield *et al.* 2005, Rossiter-Rachor *et al.* 2009,) to other plants within the ecosystem it invades.

Another challenge is controlling gamba grass in difficult to access areas. For some other weeds like lantana (*Lantana camara*) and Siam weed (*Chromolaena odorata*), the use of low volume high concentration applications using backpack style equipment has proven effective (e.g. Somerville *et al.* 2011, Brooks *et al.* 2014). In this study we tested whether this approach could be used to effectively control gamba grass. A rate response trial was implemented whereby six rates of glyphosate were applied to gamba grass using splatter gun style equipment, and efficacy compared against an untreated control.

MATERIALS AND METHODS

Site details A cattle property approximately 50 km south-west of Mount Garnet in far north Queensland (18°02'23.9"S 144°52'32.2"E) was used for this trial. It had a patch of gamba grass growing at a density of about 15, 000 plants ha^{-1} in a cleared area, with a predominately red earth soil type. To provide a uniform trial area, the experimental site was slashed 140 days prior to treatment (13 December 2017), and cattle were excluded thereafter with electric fencing. The trial was established in April 2018, and treatments implemented on 3 May 2018. In the year preceding, and the year of the experiment, the area received average (723 mm) and above average (996 mm) rainfall, respectively, compared to the 10-year annual average of 722 mm (Queensland Government 2020).


(a)


(b)


(c)


(d)

Figure 1. Experimental trial site (a) prior to and (b) after slashing in December 2017. The area was (c) fenced at the time of slashing to exclude livestock and (d) individual plants designated for treatment were marked with white pegs in early May 2018.

Experimental design The experiment was undertaken using a randomized complete block design, and compared the efficacy of six application rates of glyphosate against an untreated control treatment. Glyphosate rates used were 9, 18, 27, 36, 45 and 54 g a.i. L^{-1}, corresponding to Roundup® herbicide (360 g a.i. L^{-1}) mixture rates of 25, 50, 75, 100, 125 and 150 mL L^{-1}, respectively. There were three replicates per treatment. Each replicate plot contained a cluster of 15 tagged gamba grass plants, and 2 m buffers surrounded each plot.

Water was used as a carrier and each mixture also contained 2 mL L^{-1} Pulse® Penetrant (1020g/L Polyether modified polysiloxane; Nufarm Australia, Laverton North, Vic.). Treatments were implemented on 3 May 2018 between 13:00 and 16:00 using a gas powered 'Forestmaster' applicator (N.J. Phillips®) set to deliver 4 mL shots via a fan nozzle adjusted to spray to a width of c.a. 30 cm. Plants received 4 mL of mixture per half metre of plant height. Shots were applied to individual plants in a single strip beginning at the top of the plant and ending at the bottom of the plant. Each plant received an average of 15 ± 2 mL of herbicide mixture. Environmental conditions during herbicide application ranged from 23─32°C, 41─70% relative humidity, 20─80% cloud cover and 0.6─1.0 km h^{-1} wind speed.

Data collection A 1 m tall wooden peg was inserted at the base of each of 315 monitored plants, which were assigned a unique identification number. Visual monitoring of leaf injury (brownout), plant health, regrowth height and presence/absence of crown moisture was conducted monthly for 13 months after treatment (MAT). Brownout (%) was estimated as the proportion of leaves exhibiting necrosis, expressed as a percentage of all leaves on the plant. Plant health was assessed using a 10-point rating scale: (1) biomass erect, 100% green; (2) biomass erect 50–99% green; (3) biomass semi-erect, 5–49% green; (4) biomass semi-erect, yellow-green; (5) biomass semi-erect, 0% green; (6) biomass erect, 100% brownout; (7) biomass collapsing, 100% brownout; (8) biomass near flat, 100% brownout; (9) biomass flat to ground, 100% brownout; and (10) no biomass remaining. Regrowth height of surviving plants was measured as the standing height (i.e., not pulled straight prior to measurement). Plant mortality (%) was calculated as the number of dead plants expressed as a percentage of the total number of plants. Plants were classified as dead once they displayed 100% brownout (health rating of 6 or higher) with no subsequent regrowth.

Statistical analysis All data analysis was conducted using Minitab®, Version 17.3.1 (Minitab Pty Ltd, Sydney, Australia). Data expressed as percentages (i.e. brownout and plant mortality) were arcsine transformed prior to analysis and then back transformed for presentation within tables or graphs. All data were subjected to an analysis of variance using a general linear model that included herbicide treatment as a fixed effect and block as a random effect. Means were compared using Fisher's least significant difference (LSD) test at a significance level of 0.05. Binary logistic regression with a confidence interval of 95% was used to model the relationship between glyphosate concentration in the herbicide mixture and plant mortality 3 MAT.

RESULTS

The Gamba grass plants were all flowering at the time of treatment, and had an average height of 1.9 ± 0.3 m, and basal circumference of 1.0 ± 0.3 m.

The three highest rates of splatter gun application (36, 45 and 54 g a.i. L-1) produced 100% mortality at 3 MAT (Table 1). The lower rates of glyphosate achieved 29–80% mortality 3 MAT with no further mortality over time. By 13 MAT, regrowth had occurred in 99% of all surviving plants. Those treated with 9 g a.i. L^{-1} glyphosate displayed regrowth 2 months earlier than plants treated with higher glyphosate rates.

Surviving glyphosate-treated plants showed stunted regrowth compared to untreated plants (Table 1). This difference was most pronounced 10 MAT, as regrowth heights began to plateau or fall after that due to stem lodging. Furthermore, a strong (R^2 = 0.93; P <0.001) sigmoidal, dose-dependent relationship was observed for plant mortality (Figure 2).

Table 1. Responses of gamba grass plants to splatter gun application of different rates of glyphosate.

Glyphosate rate g a.i. L[1]	Plant health score 13 MAT[1]	Mortality (%) 3 MAT[1]	Regrowth Height (cm) 10 MAT[1]
0(control)[2]	2.0 d	0 e	73 a
9	3.5 c	29 d	63 b
18	5.7 b	69 c	47 c
27	6.5 b	80 b	41 c
36	7.5 a	100 a	-
45	7.3 a	100 a	-
54	7.5 a	100 a	-

[1] Means within a column that do not share a letter are significantly different (P < 0.05) according to Fisher's LSD test. [2] Untreated plants served as a control treatment.

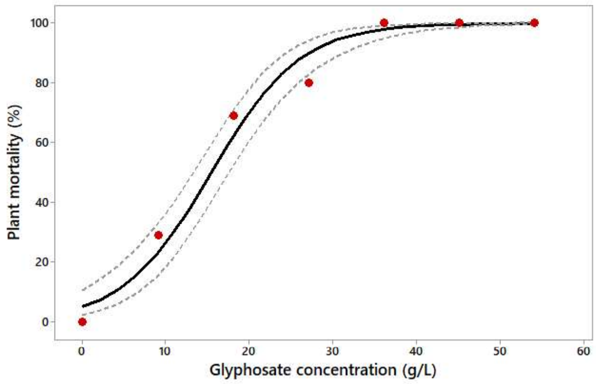

Figure 2. Relationship between gamba grass plant mortality 3 MAT and glyphosate concentration in splatter gun applied herbicide mixture. Data points represent treatment means. Solid line represents a binary logistic regression equation (mortality rate = exp(-2.905 + 0.1887 glyphosate concentration)/(1 + exp(-2.905 + 0.1887 × glyphosate concentration); R^2 = 0.93; P <0.001), in which mortality rate as a proportion has been converted to a percentage. Dotted lines represent 95% confidence interval.

DISCUSSION

The findings from this experiment suggest that 36 g a.i. L^{-1} glyphosate is the optimal rate for controlling gamba grass via splatter gun application, as it is the lowest rate capable of achieving 100% mortality within 3 MAT. It is important to note however that this trial was undertaken on gamba grass regrowth and a follow up trial has been undertaken on more mature gamba grass plants to determine if similar results can be achieved. If effective, low volume high concentration herbicide application is advantageous in that it requires a smaller volume of herbicide, so can be useful where access is difficult, e.g., on hillsides. Gas-powered applicators are also available and very suitable for larger infestations. The weight of herbicide mix, as well as the amount of water required to create the mix, can be greatly reduced when using splatter application. Another advantage is that the gamba grass clumps are specifically targeted, resulting in less wastage and off-target damage. Brooks *et al* (2014) noted that "Low-volume high concentration applications of herbicide provide an additional treatment option for areas not accessible to high-volume ground-based spray equipment."

Although splatter application of glyphosate was highly effective, further research into alternative herbicides is warranted, due to potential future issues with glyphosate resistance, and possible regulatory restrictions. Any herbicide treatment that displayed a pre-emergent effect, e.g. possibly flupropanate, could also be highly valuable.

Campbell *et al* (2019) used the splatter technique on rubber vine *(Cryptostegia grandiflora)*, prickly acacia (*Vachellia nilotica*), and Chinee apple (*Ziziphus mauritiana*), and noted some variability in results, indicating that "many factors may affect efficacy, including the health, size and density of plants, herbicide choice and mixture/application rate, presence/absence of biological control agents and climatic conditions".

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