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Optimising spot spraying for controlling Guinea grass

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Abstract Established Guinea grass stools are commonly found in our sugarcane-farming system. No registered herbicides that are both effective on perennial Guinea grass stools and selective to sugarcane are available. Directed-spray strategies using registered herbicides and current spray configurations are not effective in controlling Guinea grass stools, so growers with Guinea grass escapes rely on spot spraying. To optimise spot spraying, the mixture applied needs to be effective in a single application with minimal impact on the adjacent sugarcane stools. Two pot trials screened herbicides registered in sugarcane for their efficacy to control established Guinea grass stools. The first pot trial showed that good spray coverage was crucial for successful control of Guinea grass spot sprayed with 1.35 L per 100 L of Weedmaster® Argo® (glyphosate 540 g/L) + 0.3 L of LI700* per 100 L. The second pot trial showed that isoxaflutole (75 g/ha) + MSMA (2.16 kg/ha) was the most effective herbicide combination and the application rate could potentially be reduced. Bobcat® i-MAXX (imazapic 25 g/L + hexazinone 125 g/L) was also effective when used at 2 L per 100 L, but Barrage® (diuron 468 g/kg + hexazinone 132 g/kg) was only effective when used at twice the recommended rate (2 L per 100 L) and only when the entire foliage was soaked to the point of runoff. The most effective spot-spraying options for Guinea grass control with the lowest impact on adjacent sugarcane were: isoxaflutole + MSMA, but this mixture is not registered for spot spraying application; and Bobcat® i-MAXX. Bobcat® i-MAXX SG (granular formulation), registered since 2018, includes a spot-spraying rate at 350 g per 100 L that is equivalent to the effective rate tested in the second pot trial.

Key words Guinea grass, *Megathyrsus maximus* var. *maximus*, directed spray, spot spray, isoxaflutole, MSMA

INTRODUCTION

Guinea grass (*Megathyrsus maximus* var. *maximus*) is a major weed in our sugarcane-farming system. Sugarcane-growing conditions are ideal for Guinea grass, which is a main weed-management issue in all sugarcane districts in Australia (Osten 2010). Guinea grass is a tufted, summer-growing perennial grass introduced in the early 1900s from Africa as a pasture crop. Mature Guinea grass is leafy, clump forming and up to 3 m high (Wilson *et al*. 1995). When it has escaped grazing paddocks, Guinea grass has invaded riparian areas, roadsides and fence lines, all of which serve as reservoirs of seed material. Guinea grass seeds can be easily spread by flood water, animal fur and contaminated soil on vehicles and machinery (Anon. 2013). The cultivar Hamil is also present in the Wet Tropics (Cook 2008). It is a giant form of Guinea grass (up to 4 m tall), more robust and coarser than common Guinea grass (Cook *et al.* 2005). While new seedlings are easily controlled using effective pre-emergent and early post-emergent herbicides, optimum spray windows are often missed, and established Guinea grass stools are commonly found in sugarcane paddocks. Trash blanketing in ratoon sugarcane does not stop established Guinea grass stools, and, since the introduction of green-cane trash-blanket farming system, the Guinea grass problem has been aggravated (Hogarth and Allsopp 2000).

Removal of established Guinea grass stools has always been problematic as herbicides effective on Guinea grass also damage sugarcane (also a perennial grass) with significant yield loss. In Queensland, spot-spraying strategies that target only the Guinea grass stools are the most common methods to target isolated Guinea grass stools with minimum impact on sugarcane. These spot-spraying strategies usually involve the use of herbicidal active ingredients such as hexazinone, MSMA, diuron and glyphosate (Osten 2010). Chemical removal with non-selective herbicides, such as glyphosate, can sometimes be ineffective on the larger stools and mechanical removal with a backhoe remains the only option (Santo *et al.* 2000). When established Guinea grass stools are widespread, an early plough-out of the sugarcane crop is the only alternative (Hogarth and Allsopp 2000).

Spot spraying is time consuming and often requires multiple passes. Failure to control Guinea grass after one spot-spray application is commonly reported, likely due to plant hardiness (deep, dense, fibrous root system) or inadequate spray application. Here, we investigate the impact of spray coverage and plant moisture stress on the efficacy of glyphosate.

Spot-spraying damage to the adjacent sugarcane stools can also be problematic as it can create an ideal gap in the crop for new Guinea grass to germinate and prosper. The use of non-selective herbicides, such as glyphosate, in the crop can compromise the survival of the adjacent sugarcane (Mason 1980).

As unreliable results with non-selective herbicides other than glyphosate are often reported, we have studied different rates and concentrations of these herbicides in order to optimise their application. Their efficacy to control Guinea grass stools when spot sprayed was determined. Our objective was to find a herbicide, or a herbicide mix, effective after a single spot-spray application.

METHODOLOGY

We established two pot trials to investigate the efficacy of several herbicides and mixes spot-sprayed on Guinea grass stools. Pot trial 1 investigated the impact of spray coverage and/or water stress on glyphosate efficacy to control Guinea grass stools (Table 1). Pot trial 2 compared the efficacies of different combinations of products, concentrations and water rate to control Guinea grass stools (Table 2).

Table 1. Details of treatments in pot trial 1.

Treatment	Water regime	Spray coverage	Product	Active and concentration	Rate (per 100 L)	Spray volume
T1	Dry	Total	Weedmaster® Argo®[1]	Glyphosate 540 g/L	1.35 L	2000 L/ha (equivalent to 117 mL per plant)
T2	Dry	Half				
T3	Wet	Total				
T4	Wet	Half				

[1] Plus adjuvant: LI 700* at 0.3%

Table 2. Details of treatments in pot trial 2.

Treatment	Product	Active and concentration	Rate in kg or L per 100 L	Speed (equivalent spray volume)
T1	Barrage®[1]	Diuron 468 g/kg Hexazinone 132 g/kg	1	1.7 km/h runoff point (2000 L/ha)
T2			1	3.4 km/h (1000 L/ha)
T3			2	1.7 km/h
T4			2	3.4 km/h
T5	Balance® 750WG + Daconate®[2]	Isoxaflutole 750 g/kg MSMA 800 g/L	0.075 + 1.5	1.7 km/h
T6			0.075 + 1.5	3.4 km/h
T7			0.15 + 3	1.7 km/h
T8			0.15 + 3	3.4 km/h
T9	Bobcat® i-MAXX[3]	Imazapic 25 g/L Hexazinone 125 g/L	1	1.7 km/h
T10			1	3.4 km/h
T11			2	1.7 km/h
T12			2	3.4 km/h
Control				

[1]Plus adjuvant: BS1000 at 0.5%
[2]Plus adjuvant: Agral at 0.2%
[3]Plus adjuvant: Activator® at 0.125%

In both trials, Guinea grass stools (cultivar Hamil) were dug out from the Mulgrave River bank and re-potted in 30-cm pots filled with potting mix. Pots were placed undercover in their randomised position. Both pot trials were designed as randomised complete blocks with four replicates. Plants were trimmed, then sprayed as the new growth was about 0.75 m high.

In pot trial 1, spraying was delayed until the appearance of seed heads. The application of glyphosate at early head stage is recommended to ensure better translocation down to the root system (Anon. 2016). In both trials, the pots were lined up and sprayed with a boom placed about 50 cm above the canopy. Two high-flow air-inducted nozzles (white 08) were used at very low speed (1.7 km/h). With this set up, the desired spot spraying rate to the point of runoff was achieved. In our experiment, the point of runoff was equivalent to 2000 L/ha.

In pot trial 1, drip irrigation was delivered for 1 minute five times a day for the 'dry' treatment and for 5 minutes five times a day for the 'wet' treatment. To confine the spray to 'half coverage' of the grass stools, half of the leaves were wrapped in GLAD Cling Wrap whilst the other half of the plant was sprayed. After spraying, plants were unwrapped and pots were returned to their previous randomised position and water regime.

In both trials, visual phytotoxicity ratings were assessed at 3 and 7 days after spraying and then weekly. We used the European Weed Research Council (EWRC) phytotoxicity rating (1-healthy plant, 9-dead plant). The chlorophyll content of leaves was measured using a SPAD 502 chlorophyll meter. The chlorophyll value (referred to as the SPAD value) was only relevant for the first five dates in pot trial 1 as SPAD measurements were ineffective on desiccated leaves.

For pot trial 1, we used a linear mixed model using ASReml-R (Butler 2009) to determine the effect of the treatments on phytotoxicity rating and on SPAD value, using a repeated measurement analysis. An '*ln*' transformation was applied on phytotoxicity rating before fitting a mixed model to the transformed data. The model assumptions were that the residuals were normally distributed, they had a constant variance and were independent, and that the factor-level variances were equal for the treatments (tested using the Brown-Forsythe Test).

For pot trial 2, statistical analysis of data used the linear mixed model procedure of SAS. Phytotoxicity ratings were treated as repeated measurements in the analysis model as they were recorded at repeated time intervals in days. Phytotoxicity rating was not a continuous variable, so a Box-Cox transformation was applied to it before fitting a mixed model to the transformed data. A linear mixed model that accounted for the covariance between the repeated measurements by fitting an appropriate covariance structure, in this case 'sp(pow)' (spatial power law) that accounts for correlations declining as a function of time, was fitted for the phytotoxicity rating.

For both trial data, if there was significant evidence from the model that the explanatory variable means differed, we used Tukey's multiple comparison test to determine which of the means were different at a family significance level of 5%.

RESULTS AND INTERPRETATION

Pot trial 1: Glyphosate to control Guinea grass

Phytotoxicity on Guinea grass

Statistical analysis showed no significant interaction of Water regime by Spray coverage by Date (P=0.184), but there was a significant effect of the interaction of Water regime by Spray coverage (P=0.02). Results from the mean comparisons are given in Figure 1.

Entirely sprayed Guinea grass stools ('Total') displayed stronger symptoms and appeared dead as soon as 3 weeks after spraying with no significant difference related to their hydration level at time of spraying. Guinea grass stools that were only partially sprayed ('Half') and without water stress ('Wet') displayed less toxicity symptoms than the entirely sprayed stools ('Total').

This result illustrates the need to ensure full coverage when spot-spraying Guinea grass stools with glyphosate, especially when the plants are not water stressed.

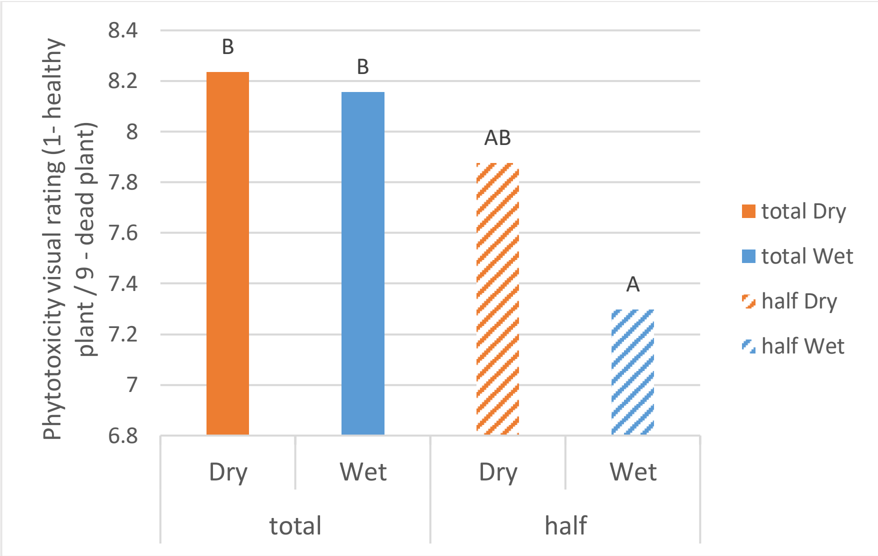

Figure 1. Mean of phytotoxicity visual rating on Guinea grass in pot trial 1 (grouped for all assessment dates). Same letter means no significant difference among treatments.

SPAD measurements

Statistical analysis showed no significant interaction of Water regime by Spray coverage by Date (P=0.514) and no significant interaction of Water regime by Spray coverage (P=0.183). However, there was a significant effect for the variable Spray coverage (P<0.001) and a significant effect for the interaction of Water regime by Date (P=0.009). Results from the mean comparisons are shown in Figure 2. The SPAD values were significantly lower for the treatment 'Total' spray coverage and for the fully hydrated grasses at the last assessment date. Lower values mean lower chlorophyll contents. These results confirmed the phytotoxicity ratings that showed that fully hydrated, half-sprayed grasses were least affected by the glyphosate treatment.

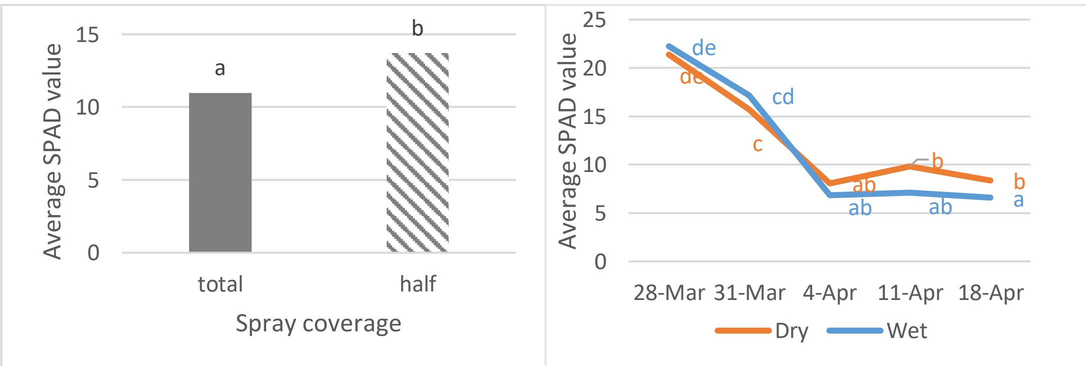

Figure 2. Mean of SPAD values on Guinea grass in pot trial 1 (grouped for date and water regime: left graph; grouped for spray coverage: right graph). Same letter within a graph means no significant difference between treatments.

Discussion pot trial 1

Spray coverage was the most crucial factor for successful control of Guinea grass. Partial (half) coverage resulted in a delayed control and ultimately plant survival when the plants were not water stressed. Glyphosate is an active ingredient that translocates through the plant; however, this translocation is a slow phenomenon and may not always achieve full control.

Unexpectedly, water stress actually contributed to a better treatment efficacy especially for the half spray coverage - the herbicide treatments were quicker to kill the water-stressed plants when compared to the fully hydrated plants. Most glyphosate labels state: "Apply to actively growing plants. DO NOT apply to drought stressed plants", because the stress reduces sap flow and, therefore, translocation of the herbicide. In our experiment, the volume of irrigation was reduced for 1 week before being totally stopped to obtain plants displaying water-stress symptoms. During this 10-day period of low irrigation for the water stressed treatment, further induction to flowering was triggered (more seed heads were visible in the 'dry' treatment). This difference in the physiological stage may have favoured the translocation of the herbicide into the root system and achieved a better kill. Interestingly, Weedmaster® Argo® label does not mention any effect of drought stress when spraying perennial weeds, but the importance of targeting the seed-head stage. This supports our results.

Pot trial 2: Alternatives to glyphosate to control Guinea grass

Phytotoxicity on Guinea grass

Statistical analysis showed a significant interaction of Treatment by Date (P <0.0001). Figure 3 displays the means for each treatment at each assessment date. This graph helps understand the efficacy dynamic for each treatment, with some treatments resulting in strong symptoms soon after spraying but followed by plant recovery. Results from the mean comparisons at the last assessment date are presented in Table 3. The last assessment, taken 4 months after spraying, is the best indication of final performance of the treatments to control the grasses.

Balance® + Daconate® was the most effective treatment at all tested application rates and speed. Application speed could be doubled without affecting the treatment efficacy. In other words, this treatment could be applied below the point of runoff without reducing its efficacy.

Bobcat® i-MAXX was only effective when used at the higher rate of 2 L per 100 L. At this rate, both speeds were efficient even if the slowest speed (point of runoff) worked faster.

Barrage® was only effective when used at twice the recommended label rate (2 L per 100 L) and only for the lower application speed, which achieved the point of runoff.

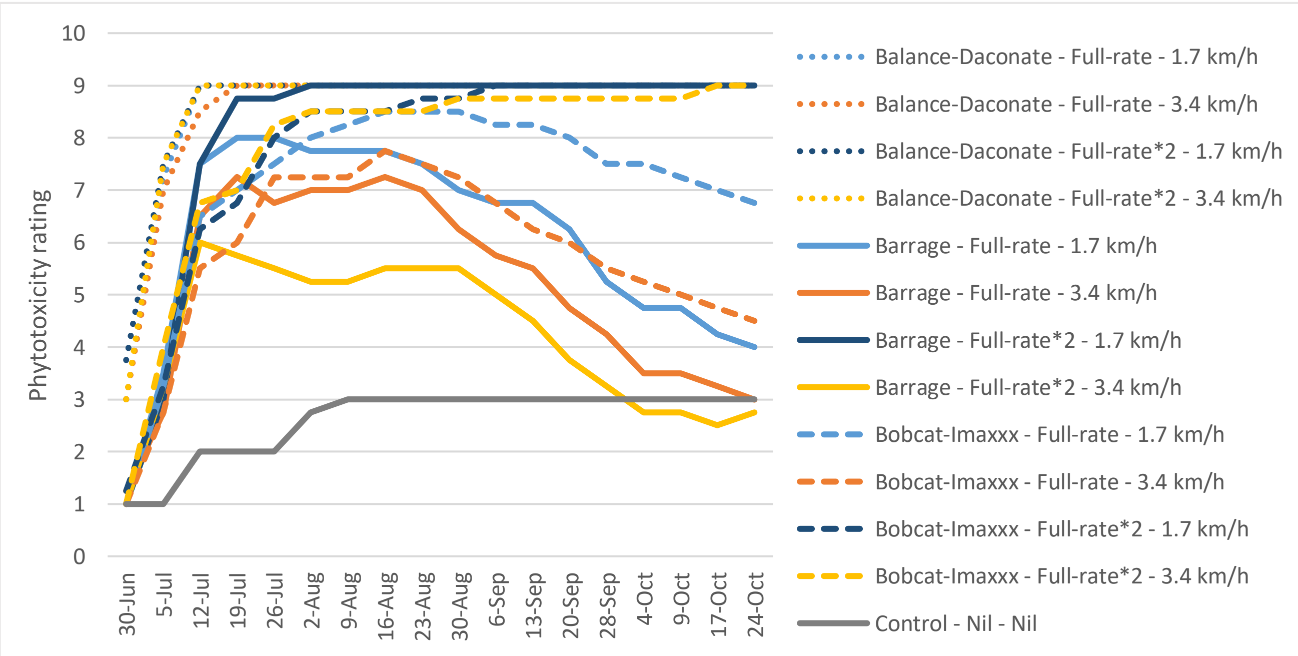

Figure 3. Phytotoxicity ratings for the 18 assessments in pot trial 2.

Table 3. Mean comparisons of the of the effect Treatment by Date for the final assessment of phytotoxicity ratings in pot trial 2.

T	Treatment description	DAT	Estimate[1]	Standard error	Back transformed variable[2]	Letter group
8	Balance® + Daconate® – Full rate x 2 – 3.4 km/h	116	9.00	0.553	8.772	A
11	Bobcat® i-MAXX – Full rate x 2 – 1.7 km/h	116	9.00	0.553	8.772	A
5	Balance® + Daconate® – Full rate – 1.7 km/h	116	9.00	0.553	8.772	A
6	Balance® + Daconate® – Full rate – 3.4 km/h	116	9.00	0.553	8.772	A
7	Balance® + Daconate® – Full rate x 2 – 1.7 km/h	116	9.00	0.553	8.772	A
3	Barrage® – Full rate x 2 – 1.7 km/h	116	9.00	0.553	8.772	A
12	Bobcat® i-MAXX – Full rate x 2 – 3.4 km/h	116	9.00	0.553	8.772	A
9	Bobcat® i-MAXX – Full rate – 1.7 km/h	116	6.75	0.553	6.941	AB
10	Bobcat® i-MAXX – Full rate – 3.4 km/h	116	4.50	0.553	5.059	BC
1	Barrage® – Full rate – 1.7 km/h	116	4.00	0.553	4.632	BC
13	Control	116	3.00	0.553	3.766	C
2	Barrage® – Full rate – 3.4 km/h	116	3.00	0.553	3.766	C
4	Barrage® – Full rate x 2 – 3.4 km/h	116	2.75	0.553	3.546	C

[1]Transformed variable
[2]Variable back transformed to its original, non-transformed measurement scale

Discussion pot trial 2

Pot trial 2 showed a range of efficient herbicides to control Guinea grass using spot spraying.

Balance® + Daconate® was the most effective treatment in this trial and the commonly used rate of 0.075 kg per 100 L of Balance® + 1.5 L per 100 L of Daconate® was more than adequate to achieve effective control. Balance® + Daconate® is currently not registered for spot spraying perennial grasses, but it is commonly used, as both herbicides are registered for broadcast application in sugarcane. Our results could be used to extend their current registration in order to include the spot-spraying application. A faster spray speed, which did not achieve the point of runoff on the grass leaves, still resulted in full efficacy. The spray rate may potentially be lowered further, but more trials are required to identify the efficacy threshold.

Bobcat® i-MAXX efficacy was optimum when used at 2 L per 100 L. At this rate, both speeds were efficient even if the slower speed worked faster. Bobcat® i-MAXX SG (150 g/kg imazapic + 750 g/kg hexazinone) is a new granular formulation registered in 2018. The label includes a spot-spraying rate at 350 g per 100 L; our tested rate of 2 L per 100L is equivalent to that spot-spraying rate.

Barrage® was only effective when used at twice the recommended rate (2 L per 100 L) and only for the lower speed, which achieved the point of runoff. These results confirm growers' observations that regrowth of perennial grasses can occur when using Barrage®. Growers have noticed it is necessary to drench the perennial grass stools with Barrage® to achieve good control. Another option identified in our pot trial is to double the concentration of the spray mix, but this is not covered by the product's registration and would require a label change before being used commercially.

Currently, Bobcat® i-MAXX SG is the most efficient strategy to control Guinea grass that is registered for spot spraying in sugarcane.

Observations on adjacent sugarcane stools made in separate field trials (data not shown) indicate that the Balance® + Daconate® treatment is the one with the least impact on sugarcane, whereas Weedmaster® Argo® and Bobcat® i-MAXX tend to produce longer-term sugarcane damage.

CONCLUSIONS

Results from our pot trials showed that there are effective options to control Guinea grass by spot-spraying in a single application. However, these directions for use need to be incorporated on some of the product labels before being used legally.

However, as spot spraying remains a labour-intensive and time-consuming operation that also relies on the operator's ability to positively identify and spray each individual Guinea grass stool and ensure an adequate spray coverage of the grass with minimum overspray on sugarcane, it should only be considered as a rescue strategy. Controlling the Guinea grass seed bank in fallows, avoiding plough-out/replant in paddocks with Guinea grass infestations and controlling young seedlings in plant sugarcane are the preferred long-term Guinea grass control strategies.

Research on automated spot-spraying options for Guinea grass stools is ongoing at the University of Southern Queensland (McCarthy *et al*. 2010). If successful automated sensors are developed, our pot trial results could be used as baseline data to develop an automated spraying system.

ACKNOWLEDGEMENTS

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