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Can directed-spray strategies control Guinea grass stools?

EF Fillols and TN Staier

Sugar Research Australia Limited, Gordonvale, Qld 4865; efillols@sugarresearch.com.au

Abstract Guinea grass is a troublesome perennial grass in our sugarcane farming system. Despite a range of effective pre-emergent and early post-emergent herbicides, optimum spray windows are often missed and established Guinea grass stools are commonly found. To control established Guinea grass stools, growers often rely on spot spraying, which is time consuming and often requires multiple passes. Four replicated field trials were established to assess if directed-spray strategies could replace spot-spraying strategies. Field trials showed that a late application of isoxaflutole (75 g/ha) + MSMA (2.16 kg/ha) applied at the base of the row generated the strongest phytotoxicity symptoms on Guinea grass stools and reduced by up to 67% the number of Guinea grass stools in the following ratoon. However, this herbicide mixture also reduced sugarcane yield by 34-41% depending on the application technique. The safest treatment for sugarcane was an early banded spray with asulam (3.4 kg/ha), followed by a late interrow application of glyphosate (2.7 kg/ha) using a shielded sprayer, but the reduction in the number of Guinea grass in the following year was highly variable from trial to trial (0-67% reduction). No directed-spray strategies were identified to control established Guinea grass in sugarcane rows without a significant sugarcane-yield penalty.

Key words Guinea grass, *Megathyrsus maximus*, directed spray, isoxaflutole, MSMA, glyphosate

INTRODUCTION

Guinea grass (*Megathyrsus maximus* var. *maximus*) is a major weed in our sugarcane-farming system. Guinea grass is a tufted, summer-growing perennial grass introduced from Africa. Mature Guinea grass is leafy, clump forming and up to 3 m high (Wilson *et al.* 1995). Guinea grass has been identified as one of the most problematic weed issues in all sugarcane-growing areas from Bundaberg to far northern Queensland. In the Wet Tropics, the cultivar Hamil is also present (Cook 2008). It is a giant form of Guinea grass (up to 4 m tall) and is more robust and coarser than common Guinea grass (Cook *et al.* 2005).

Green-cane trash-blanketing prevents germination of most grasses but does not stop the regrowth of Guinea grass stools after harvest and, since the introduction of green-cane trash -lanket farming system, the Guinea grass problem has increased (Hogarth and Allsopp 2000). When it has escaped paddocks, Guinea grass has also invaded riparian areas, roadsides and fence lines, which serve as reservoirs of seed material. Guinea grass seeds can be easily spread by floodwater, animal fur and contaminated soil on vehicles and machinery (Anon. 2013).

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. No selective herbicides registered on sugarcane in Australia control established Guinea grass stools and herbicides effective on Guinea grass also damage sugarcane with significant yield loss. Therefore, spot-spraying strategies that targets only the Guinea grass stools are the most common method to target isolated Guinea grass stools with minimum impact on sugarcane. These spot-spraying strategies involve the use of herbicidal ingredients such as hexazinone, MSMA, diuron and glyphosate (Osten 2010; Fillols and Staier 2019). However, spot spraying is labour intensive and time consuming. It depends on the ability of the operator to identify each Guinea grass stool without missing any and to ensure optimal spray coverage.

McCarthy *et al.* (2010) assessed the potential of machine vision for detecting *M. maximus* to allow spot spraying in sugarcane crops but further development is still required. In the meantime, we explore the potential of directed-spray strategies to control established Guinea grass stools as an alternative to spot spraying. Directed-spray strategies are much more cost effective as many rows of sugarcane are sprayed at the normal spraying speed. Different directed-spray implements are in use in Australia. The octopus leg with six nozzles spraying the interrow and the base of the row is the most common application method when the height of the sugarcane canopy exceeds about 1 m to limit spray coverage on new sugarcane leaves. Band spraying over the row is a common method to apply sugarcane-selective herbicides and control weeds in the row when the sugarcane is still short. Occasionally, growers can use a shielded sprayer to safely spray glyphosate in the interrow or a QDAF dual-spray bar (DHSB) (Ross 2015; Blair *et al.* 2019) that direct-sprays glyphosate in the centre of the interrow without a shield.

The challenge with all these application methods is to get an optimum herbicide coverage of the Guinea grass stools whilst minimising the spray coverage on the sugarcane. Unfortunately, Guinea grass regrowth and sugarcane ratoons have similar growth patterns, translating into plants of similar height and making spray coverage discrimination almost impossible.

Here, we determine the efficacy of directed-spray strategies on established Guinea grass stools and their off-target impact on sugarcane yield. We compare different directed-spray strategies to determine their efficacy in controlling established Guinea grass stools.

Table 1. Herbicide treatments in the field trials.

Treatment	Timing	Product	Active and concentration	Rate kg/ha or L/ha	Water rate L/ha
T1 (band sprayed over the row)	Early post-emergent application	Rattler® 400[2]	Asulam 400 g/L	8.5	400
T1 (sprayed interrow with shield)	Late post-emergent application[1]	Weedmaster® Argo®[3]	Glyphosate 540 g/L	5	100
T2 (sprayed interrow + base of row using octopus leg)	Late post-emergent applications[1]	Diurex® WG[4]	Diuron 900 g/kg	0.5	350
		Shirquat® 250 (GGF1, GGF2)	Paraquat 250 g/L	1.2	350
		Daconate® (GGF3, GGF4)	MSMA 720 g/L	3	350
T3 (sprayed interrow + base of row using octopus leg)	Late post-emergent application[1]	Balance® 750WG[4]	Isoxaflutole 750 g/kg	0.1	350
		Shirquat® 250	Paraquat 250 g/L	1.2	
T4 (sprayed interrow + base of row using octopus leg)	Late post-emergent applications[1]	Balance® 750WG[4]	Isoxaflutole 750 g/kg	0.1	350
		Monopoly®	MSMA 720 g/L	3	350
T5 (sprayed interrow with shield)	Late post-emergent applications[1]	Weedmaster® Argo®[3]	Glyphosate 540 g/L	5	100
T5 (sprayed at the base of the row using shield side nozzles)		Balance® 750WG[4]	Isoxaflutole 750 g/kg	0.1	350
		Monopoly®	MSMA 720 g/L	3	350
T6 (sprayed interrow using DHSB central nozzle)	Late post-emergent applications[1]	Weedmaster® Argo®[3]	Glyphosate 540 g/L	5	100
T6 (sprayed at base of row using DHSB side nozzles)		Balance® 750WG[4]	Isoxaflutole 750 g/kg	0.1	350
		Monopoly®	MSMA 720 g/L	3	350

[1]Applications when sugarcane was 1 m high in the four trials AND additional application before out-of-hand stage in two trials (GGF3 and GGF4).
[2]Plus adjuvant: Wetspray® 1000 at 0.2%
[3]Plus adjuvant: LI 700* at 0.3%
[4]Plus adjuvant: Activator® at 0.125%

METHODOLOGY

We conducted four replicated trials in trash-blanketed ratoon crops in the Wet Tropics of northern Queensland (Gordonvale, Mirriwinni, Aloomba, Garradunga) infested with perennial Guinea grass stools (cv. Hamil). Trials were coded GGF1, GGF2, GGF3 and GGF4, respectively, and each designed as randomised complete blocks with four replicates. A pre-emergent treatment applied throughout each trial just after harvest helped to control new Guinea grass seedlings. Treatments compared in each trial are detailed in Table 1.

The efficacy of post-emergent herbicides was estimated by rating the visual symptoms on sugarcane and Guinea grass in the row and in the interrow every 2 weeks starting in each treatment from the first herbicide application. We used the European Weed Research Council (EWRC) phytotoxicity rating (1-healthy plant, 9-dead plant). At harvest, sugarcane yield was measured using a weigh truck. The number of grass plants in each plot was counted before the first treatment and after harvest. The percentage reduction in number of grass plants was calculated using the formula:
Percentage grass reduction = (initial number of grasses – final number of grasses) x 100/final number of grasses

Data from the four trials were grouped and analysed using linear mixed models using restricted maximum likelihood ASReml-R (Butler 2009). The variables 'total percentage reduction', 'phytotoxicity rating' and 'cane yield' were investigated.

The significance of the fixed terms was tested using asymptotic Wald statistics, so the F-values reported in the analysis of variance table are approximate F values (Kenward and Roger 1997). The model assumptions were that the residuals were normally distributed and had a constant variance, and that the factor level variances were equal for the treatments (tested using the Brown-Forsythe Test). The Shapiro-Wilk test was used to determine if the residuals were normally distributed.

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%. No comparison tests were carried out for any interactions involving 'number of days after spraying' as it was fitted in the model as a covariate (continuous variable). In this instance, confident intervals have been added to the graphs. When the confident intervals diverge, the treatment effects are different.

RESULTS AND INTERPRETATION

Phytotoxicity on grass

The combined analysis across the four sites showed a significant difference for the interaction of Site by Treatment by Date ($P=0.012$ for the row data, $P<0.0001$ for the interrow data). Results of analysis at each trial site are presented in Figure 1, which displays the confident interval for each treatment (left graphs are the row data, right graphs are the interrow data).

Across all sites and all dates, treatments 4 and 5 (isoxaflutole + MSMA in the row applied with octopus leg or shield side nozzles) were the most damaging on the perennial grasses in the row, especially at 30 and 45 days after treatment, whereas treatments 1 and 2 had the lowest visible impact on the grasses. Treatment 1 was an early spray of asulam over the row, followed by glyphosate in the interrow using a shield. Treatment 2 was a late application(s) of diuron low rate + paraquat (or MSMA) using an octopus leg (Figure 1, top graphs).

Across all sites and all dates, treatments 1, 5 and 6 were the most damaging on the perennial grasses in the interrow, whereas treatments 2 and 3 had the lowest visible impact on the grasses in the interrow. Treatments 1 and 5 involved the application of glyphosate with a shield, which is the most effective way to control grasses in the interrow.

Treatment 6 was also effective as it also involved the use of glyphosate without a shield. Treatments 2, 3 and 4 were all applied with an octopus leg. Among these, the best control was obtained with treatment 4 using Balance® plus Daconate® (Figure 1, bottom graphs).

Phytotoxicity on sugarcane

The combined analysis of the data across the four sites showed a significant difference for the interaction of Site by Treatment by Date ($P <0.001$). Results of analysis at each trial site are presented in Figure 2, which displays the confidence interval for each treatment.

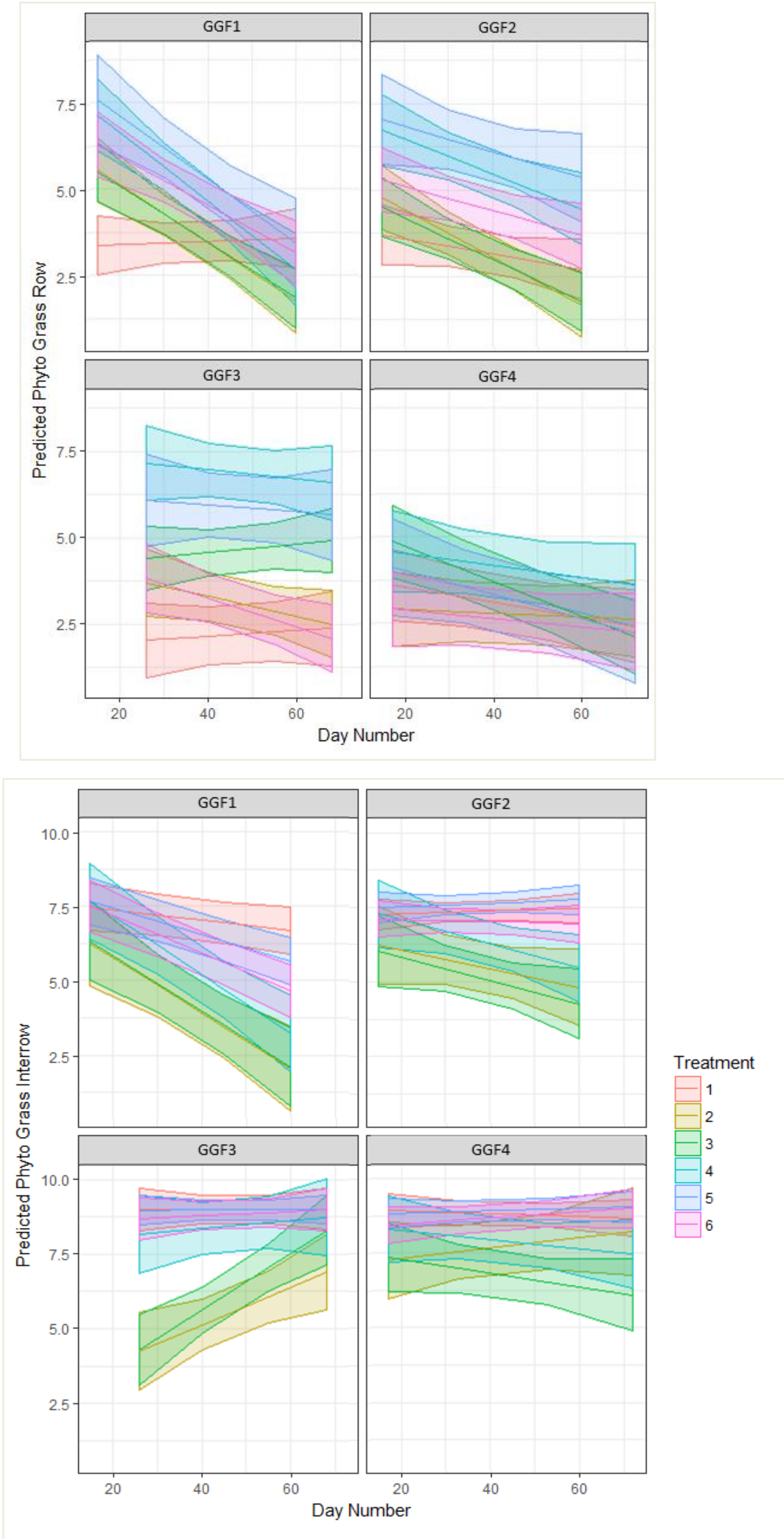

Figure 1. Mean phytotoxicity on grass in the row (top graphs) and in the interrow (bottom graphs) and confidence interval at each trial site (GGF1 to GGF4).

Across all sites and all dates, treatments 3, 4 and 5 (isoxaflutole + paraquat or MSMA) sprayed in the row using an octopus leg (T3, T4) or shield side nozzles (T5) tended to be the most damaging on sugarcane, whereas treatment 1 (asulam in the row, glyphosate sprayed under the shield) and treatment 6 (dual-spray bar with glyphosate and isoxaflutole + MSMA) had the lowest impact on sugarcane appearance. Even though T4 and T5 were the most effective on grasses, these treatments were also detrimental to sugarcane. It is interesting to note that T3 (isoxaflutole + paraquat) was more detrimental to sugarcane than to Guinea grass, which makes this product combination inadequate.

In trials GGF1 and GGF2, symptoms from treatment 1 increased overtime. The early application of asulam did not result in any phytotoxicity symptoms on sugarcane, but the following application of glyphosate with the shield created spray drift on the sugarcane row in trials GGF1 and GGF2.

It is important to note that the second application on T1 was sprayed 30 and 15 days later than the first application in GGF1 and GGF2, respectively, and therefore the curve for T1 should be shifted 30 and 15 days to the left if the second herbicide application is to be compared to the other treatments. This significant difference at 60 DAT is, therefore, mainly due to this timing artefact. No spray-drift phenomenon occurred in trials GGF3 and GGF4 as the shield was lowered further.

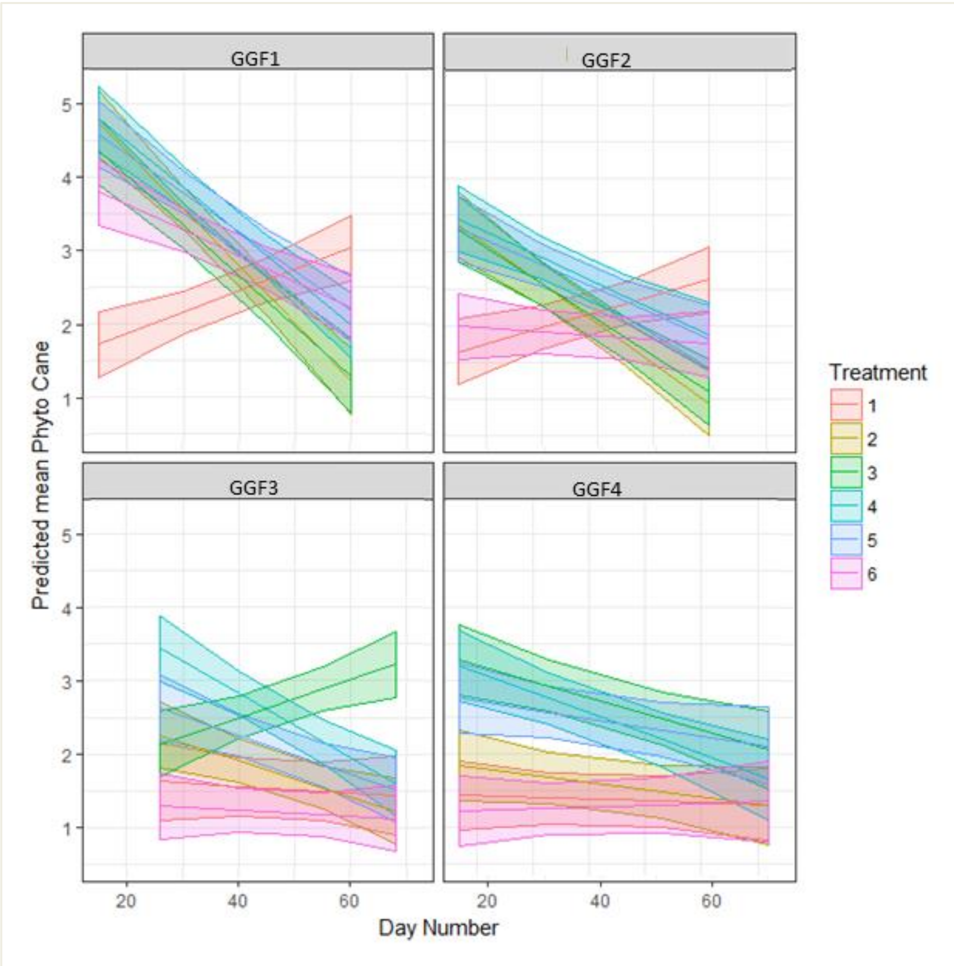

Figure 2. Mean phytotoxicity on sugarcane and confidence interval at each trial site (GGF1 to GGF4).

Percentage grass reduction

The combined analysis across three sites (GGF2, GGF3, GGF4) showed a significant difference for the interaction of Site by Treatment (P=0.036). Results are presented in Figure 3 and mean comparisons are added in the graph. No data were available for trial GGF1 (access impossible after harvest).

Results showed no significant differences among treatments at each trial site. The main differences were among sites, with 30-66% grass reduction at trial GGF2, 0-67% reduction at trial GGF3 and 4-14% reduction at trial GGF4. The differences among trials could be attributed to a variable resilience of Guinea grass dependent on the environmental conditions at each site.

Treatment 4 tended to be the most effective for long-term grass control at all sites. At best, it achieved up to 67% reduction in the number of grasses in trials GGF2 and GGF3. Treatment 1, 5 and 6 achieved about 60% long-term control but only in trial GGF2. None of these levels of control are acceptable.

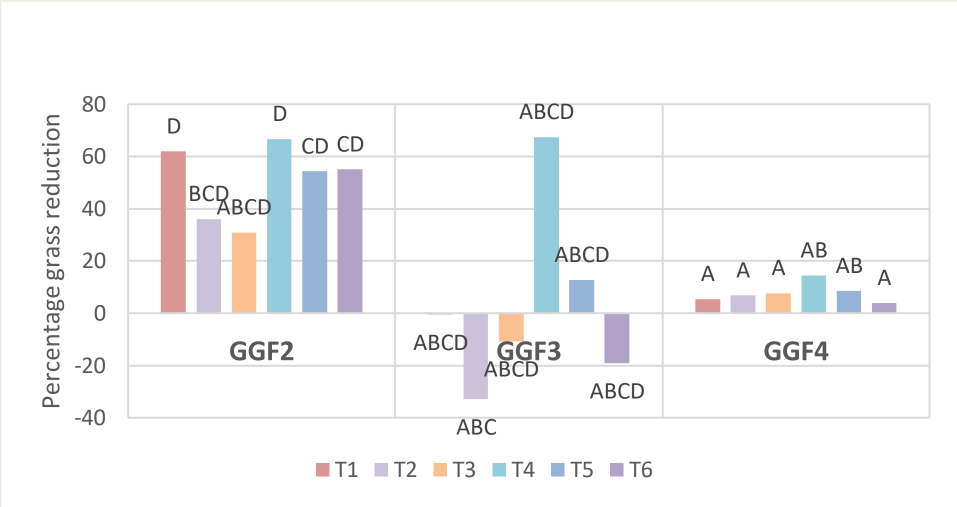

Figure 3. Mean of percentage reduction of Guinea grass in trials GG2, GGF3 and GGF4. Same letter means no significant differences among treatments.

Cane yield

The combined analysis showed no significant differences for the interaction of Site by Treatment but significant differences among treatments (P=0.003) and among sites (P=0.011). Yield data were only available for trials GGF3 and GGF4.

Treatment 1 produced higher yields than treatments 3, 4, 5 and 6 (Figure 4).

All other treatments resulted in unacceptable yield losses (about 30-40% yield loss compared to treatment 1) mainly due to direct phytotoxicity on sugarcane.

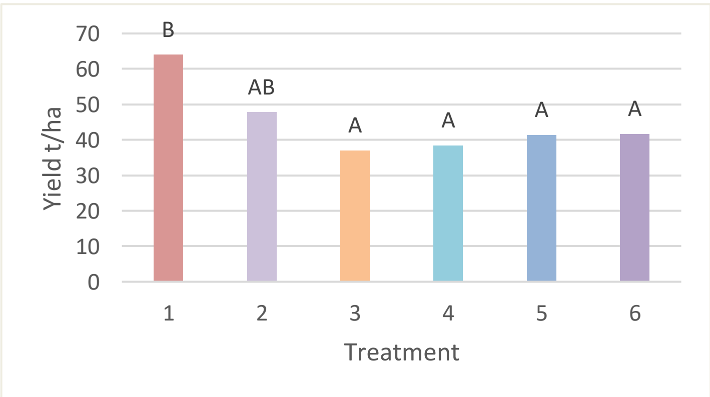

Figure 4. *Sugarcane* yields (mean of GGF3 and GGF4). Same letter means no significant differences among treatments.

DISCUSSION

None of the tested treatments resulted in acceptable control of Guinea grass in the row.

The QDAF dual-spray bar was effective in controlling grasses in the interrow, but not in the row. The conservative set-up and low height of the boom to avoid sugarcane phytotoxicity damage from glyphosate also restricted the spray coverage of isoxaflutole + MSMA on grasses in the row.

Spraying glyphosate under a shield was also very effective in controlling grasses in the interrow and appeared safe to use on sugarcane. The herbicide mix (isoxaflutole + MSMA) sprayed on grasses in the row resulted in strong phytotoxicity symptoms on the grasses due to the non-conservative set up of the side nozzles that sprayed reasonably high in the canopy. On the other hand, it also resulted in strong phytotoxicity on sugarcane and reduced the cane yields.

The octopus leg was also set up in a non-conservative manner, aiming high into the row canopy (50 cm high). Using the octopus leg, the most effective herbicides in controlling grasses in the row and in the interrow in the long term was isoxaflutole + MSMA. Grasses in the interrow were successfully controlled, but grasses in the row only displayed mild phytotoxic symptoms and their growth was only slowed down, despite a repeated treatment application. The impact on sugarcane was also quite alarming with phytotoxicity symptoms lasting more than eight weeks and resulting in lower sugarcane yields.

Isoxaflutole + paraquat applied with the octopus leg was slightly less effective on grasses (row and interrow) than isoxaflutole + MSMA, but its phytotoxicity on sugarcane was comparable or higher than isoxaflutole + MSMA and it also resulted in lower sugarcane yield.

Diuron + MSMA applied with the octopus leg was a softer option on sugarcane, but it was also less effective in controlling grasses in the row and in the interrow. It resulted in the second-highest sugarcane yield.

Asulam was very safe on sugarcane. Most sugarcane cultivars are tolerant to asulam and can rapidly metabolise it. Guinea grass, however, is susceptible to asulam, but the product label mentions “Guinea grass is only controlled at seedling stage (up to 10 cm)”. Asulam is readily absorbed by foliage and translocated in both xylem and phloem to growing points. In our trials, perennial Guinea grass stools were sprayed in their early regrowth after harvest (0.2 m high). No visual damage on Guinea grass was observed, but growth was slower than that of untreated Guinea grass. This reduction in grass growth in the early growth stage of sugarcane could have also contributed to a reduced competition with sugarcane, and combined with crop safety, resulted in higher yield. However, asulam did not achieve acceptable long-term grass control.

CONCLUSIONS

Our trials did not identify a direct-spray herbicide strategy that effectively controlled Guinea grass present in the sugarcane row whilst not affecting sugarcane yield.

Manual spot-spraying remains the only current management option to deal with established Guinea grass stools. However, as spot spraying remains a time-consuming operation with inconsistent results related to product choice and operator ability and diligence, it can only be considered as a rescue strategy.

Controlling the Guinea grass seed bank in the fallow and avoiding plough-out/replant in paddocks with Guinea grass infestation are the preferred strategies for long-term Guinea grass control. Effective pre-emergent and early post-emergent herbicides are also available to control new Guinea grass seedlings and all efforts should be made to avoid any escapes.

Research on automated spot-spraying options for Guinea grass is ongoing (McCarthy *et al.* 2010) and if successful would facilitate the management of these Guinea grass escapes.

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REFERENCES

Anon. (2013) *Weeds of the Mackay Whitsunday Region*. Mackay Regional Pest Management Group, Mackay.

Anon. (2016) *Guinea grass factsheet*. https://www.daf.qld.gov.au/__data/assets/pdf_file/0006/67398/IPA-Guinea-Grass-PP82.pdf (accessed 16 January 2019).

Blair A, Robertson J, Wright C, Blair I (2019) Non-shielded dual-spray technology for application of herbicides in sugarcane production systems. *Proceedings of the Australian Society of Sugar Cane Technologists* 41: 297–305.

Butler D (2009) asreml: asreml() fits the linear mixed model [Computer software manual]. Retrieved from www.vsni.co.uk (R package version 3.0).

Cook BG (2008) *Fact sheet: Guinea grass*. http://keys.lucidcentral.org/keys/v3/pastures/Html/Guinea_grass.htm (accessed 19 January 2019).

Cook BG, Pengelly BC, Brown SD, *et al.* (2005) *Tropical Forages: an interactive selection tool*. http://www.tropicalforages.info/key/forages/Media/Html/entities/panicum_maximum.htm (accessed 19 January 2019).

Fillols EF, Staier TN (2019) Optimising spot spraying for controlling Guinea grass. *Proceedings of the Australian Society of Sugar Cane Technologists* 41: 171–177.

Hogarth DM, Allsopp PG (eds) (2000) *Manual of cane growing.* Bureau of Sugar Experiment Stations, Brisbane.

Kenward M, Roger J (1997) Small sample inference for fixed effects from restricted maximum likelihood. *Biometrics* 53: 983–997.

McCarthy C, Rees S, Baillie C (2010) Machine vision-based weed spot spraying: a review and where next for sugarcane? *Proceedings of the Australian Society of Sugar Cane Technologists* 32: 424–432.

Osten V (2010) *Weeds scoping study report for North Queensland, Central Queensland and near coastal cropping systems 2009/2010.* Department of Employment, Economic Development and Innovation, Brisbane.

Ross P (2015) A different option for post-emergent Guinea grass control. *Australian Sugarcane* 19: 9–10.

Wilson BJ, Hawton D, Duff AA (1995) *Crop weeds of Northern Australia: identification at seedling and mature stages.* Information Series. Queensland Department of Primary Industries, Brisbane.