

Glyphosate resistance in northern New South Wales – a growing concern

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Summary Despite the low risk rating attributed to glyphosate for the development of herbicide resistance, a population of glyphosate resistant annual ryegrass (ARG) (*Lolium rigidum* Gaudin) was identified in 1998, followed by another one in 2000 in northern NSW. Seed samples were collected and tested. Both populations exhibit significant resistance to glyphosate.

A field trial was conducted in 1999 to compare a range of herbicide treatments for controlling glyphosate resistant ARG. Glyphosate at 3240 g a.e. ha⁻¹ gave 53% reduction in spikelets 90 days after treatment (DAT), while fluazifop butyl (212 g a.i. ha⁻¹), clethodim (72 g a.i. ha⁻¹), glyphosate trimesium (720 g a.e. ha⁻¹), gave 83, 96, and 8% reduction respectively.

The following year field trial was conducted in the Baradine area of NSW, on the second resistant population of ARG found, to investigate the efficacy of a range of herbicide tank-mixes.

Glyphosate (720 g a.e. ha⁻¹) and paraquat (450 g a.i. ha⁻¹) gave 71 and 95% control of ARG at 30 DAT respectively. Both 'fop' and 'dim' selective herbicides gave over 95% control. Seed samples were collected and tested. This population exhibits a similar level of glyphosate resistance as the Liverpool Plains population.

A farm survey of the lower Liverpool plains in 2001 showed that glyphosate resistant ARG is present on at least 10 properties, with infestations varying from small patches of plants to being widespread across the whole property. The main method of control that farmers were using in winter fallows was post-emergent applications of clethodim. Results of resistance testing from the survey samples are presented and implications for northern farming systems discussed.

Keywords Glyphosate, herbicide resistance, annual ryegrass, herbicides.

INTRODUCTION

Herbicide resistance is seen as a recent phenomenon by most agriculturalists in northern NSW and Queensland. In 1995 many agriculturalists considered herbicide resistance a 'southern Australian' problem with little need to change weed management practices.

Despite this attitude, resistance in broadleaf weed populations to Group B (acetolactate synthase inhibi-

tors) herbicides was already well established (Boutsalis and Powles 1995, Adkins *et al.* 1996).

Despite the discovery of glyphosate resistant annual ryegrass (ARG) (*Lolium rigidum* Gaudin) in northern Victoria in 1996 and an orchard in NSW in 1997, northern NSW and Queensland agriculturalists still considered glyphosate resistance as an extremely remote possibility. At the same time, overseas researchers were still hypothesising that naturally selected glyphosate resistance in plants was virtually impossible (Bradshaw *et al.* 1997), despite evidence to the contrary. The reasoning behind this attitude in Australia was that summer cropping was regularly practised in the cropping areas north of Dubbo, NSW, and this would automatically prevent glyphosate resistance.

In late 1998, a consultant operating on the Liverpool Plains, NSW, found that one of his clients was having difficulty controlling patches of ARG. Seed was collected from plants by NSW Agriculture and tested at Charles Sturt University, Wagga Wagga. These tests confirmed the first case of glyphosate resistant ARG in the summer cropping area of eastern Australia.

A field trial was conducted at the site of a second suspected resistance case in April, 2000. The aim was to test whether glyphosate resistance had developed on this property and what herbicide options were still available for the farmer. ARG seed from this site was lab-tested confirming glyphosate resistance.

In 2001, ARG plants were collected from around northern NSW, and grown to maturity. Seed was harvested and will be tested under laboratory conditions for resistance.

MATERIALS AND METHODS

All herbicides were applied with a 3 m wide hand-held boom, with 50 cm nozzle spacing operating at a pressure of 210 kPa. Both trials were conducted in randomised complete block designs. Analysis of variance was performed on data from both trials. Visual control assessments were made on a 0–5 scale.

Trial 1 – Liverpool Plains, NSW The ARG at the time of application was at Z15, 25 to 17, 28 stage and was actively growing on a deep brown to grey vertosol.

This trial had 15 treatments and three replicates with unit plot size of 4 m by 10 m.

Visual assessments of control were performed at 39 and 90 days after treatment (DAT).

Trial 2 – Baradine, NSW ARG plants at the time of herbicide application were at Z13-15, 25, and were actively growing. The soil was a brown vertosol with excellent moisture. This trial had 18 treatments and three replicates with unit plot size of 4 m by 10 m. Visual assessments of control and relative frequencies of ARG plants were made at 33 and 58 DAT. The trial was sprayed with MCPA LVE at 2 L ha⁻¹ to control *Rapistrum rugosum* at 58 DAT.

Survey 2001 A range of mass media was used in 2001 to highlight the issues of resistance to the rural community. Agronomists and consultants were asked to be observant for potential cases of glyphosate resistance. Reports were acted upon, collecting samples and paddock histories.

Samples were planted at the Tamworth Centre for Crop Improvement, with plots covered by quarantine enclosures. Seed was harvested when ripe.

RESULTS AND DISCUSSION

The field trials were conducted to test whether these ARG populations were resistant to glyphosate and give the farmers some quick options for management.

Field-testing is a practical approach to resistance management because the target plants are hardened as compared with glasshouse grown and tested specimens. Field tests allow the evaluation of a large number of herbicide options quickly and cheaply. This also has enormous value as an extension tool.

Trial 1 – Liverpool Plains Although 15 treatments were applied, six treatments are presented in Figure 1.

Some treatments such as atrazine performed poorly due to the advanced development of the ARG. Atrazine is not efficacious on established ARG. Glyphosate (3240 g a.e. ha⁻¹) achieved a control score under 3 (approx 70% control). Despite the ARG being well-tillered at time of herbicide application growing conditions were good. Diclofop-methyl (A) performed poorly. This is most likely due to the size of the ARG; however other glyphosate resistant populations of ARG are known to have some level of ‘fop’ resistance. Imazapyr (D) eventually gave the highest level of control. The lack of rain from July to late August delayed the uptake of imazapyr by the plants. Fluazifop (E) almost gave commercial levels of control while clethodim (F) achieved the best result at both assessment dates.

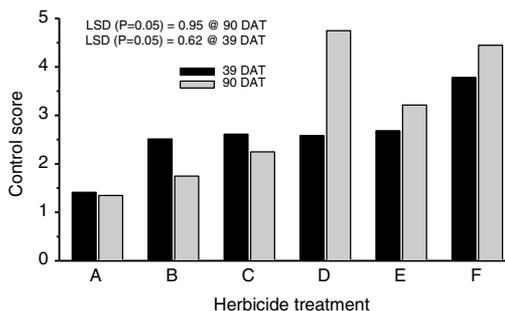


Figure 1. Effect of herbicides on glyphosate resistant ARG at 39 and 90 DAT, Liverpool Plains, 1999. Control scores 0–1 = 0–40%, 1.1–2 = 41–60%, 2.1–3 = 61–80, 3.1–4 = 81–94%, 4.1–5 = 95–100% biomass reduction. Herbicides are A = diclofop-methyl (375 g a.i. ha⁻¹), B = amitrole + ammonium thiocyanate (1400 + 1232 g a.i. ha⁻¹), C = glyphosate (3240 g a.e. ha⁻¹), D = imazapyr (375 g a.i. ha⁻¹), E = fluazifop (212 g a.i. ha⁻¹), F = clethodim (72 g a.i. ha⁻¹).

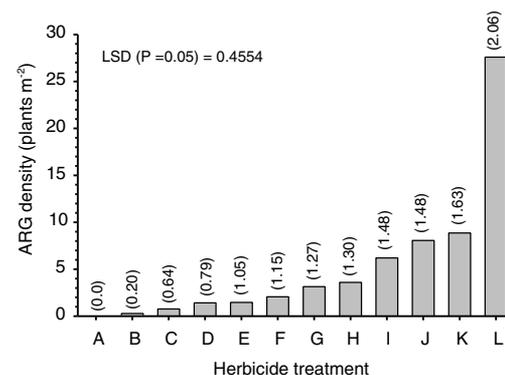


Figure 2. Effect of herbicides on glyphosate resistant ARG plant density 33 DAT, Baradine, NSW, 2000. Log transformed data presented in parentheses. A = butoxydim (30 g a.i. ha⁻¹), B = haloxyfop (39 g a.i. ha⁻¹), C = paraquat + atrazine (250 + 1500 g a.i. ha⁻¹), D = paraquat + diquat (324 + 276 g a.i. ha⁻¹), E = paraquat (450 g a.i. ha⁻¹), F = clethodim 936 g a.i. ha⁻¹, G = clethodim + glyphosate (12 + 450 g a.e. ha⁻¹), H = 2,2-DPA (7400 g a.i. ha⁻¹), I = paraquat + chlorsulfuron (250 + 19 g a.i. ha⁻¹), J = glyphosate (720 g a.e. ha⁻¹), K = amitrole + ammonium thiocyanate (1400 + 1232 g a.i. ha⁻¹), L = untreated.

Trial 2 – Baradine The ARG plants were considerably smaller at time of application compared with trial 1. Twelve treatments are presented in Figure 2 out of 18 applied. The selective grass herbicides, butoxydim

(A) and haloxyfop (B) gave excellent control. Clethodim (F) was not as efficacious as would have been expected. Paraquat + atrazine (C), paraquat + diquat (D) and paraquat alone (E) gave equal control.

A theory that 'spike' (low) rates of selective grass herbicide mixed with knockdown herbicides improved control via 'cell-leakage' was tested. A rate of 12 g a.i. clethodim + 450 g a.i. glyphosate ha⁻¹ (G) improved control over 720 g a.i. ha⁻¹ glyphosate alone, but not significantly. Addition of clethodim to half rates of amitrole and 2,2-DPA gave poorer control than the full rate of both products alone. Control from glyphosate (J) was not commercially acceptable and not significantly different from amitrole + ammonium thiocyanate (K). After these two trials it is clear that amitrole + ammonium thiocyanate and 2,2-DPA are not suitable for ARG control.

Field survey 2001 Nineteen populations of plants were collected from 12 properties. Most properties were on the southern Liverpool Plains, one from Baradine and three from the Manilla area.

Populations varied from virtually all over one property to small patches of several square metres to large individual plants surviving repeated glyphosate applications.

Currently two geographically widely separated ARG populations have been positively identified as resistant to glyphosate in the summer cropping zone of eastern Australia.

Populations of resistant ARG have 'slipped through' the winter fallow-summer crop rotation for three main reasons. Firstly all cases were no-till situations. Cultivation has been removed from the system, leading to a 'total' reliance on glyphosate for fallow weed control. Secondly, growers are not aware of the concept of seed bank management. Populations of weeds are sprayed with no control of escapes, allowing seed set and the restocking of the seedbank. Thirdly, atrazine is widely used in the winter fallow leading up to sorghum. Atrazine is only effective on ARG before Z13 (3 leaves), or as a pre-emergent. Current practices have atrazine being applied to fallows when surviving ARG plants are too large to be controlled. Earlier application of atrazine with paraquat or Spray.Seed® will lead to better control, as demonstrated in trial 2.

Both trials showed that the selective grass herbicides appear effective, particularly the 'dims'. The survey highlighted, however, that most farmers who suspect resistance immediately turn to clethodim to control escapes from glyphosate. Under current herbicide resistance management strategies, clethodim and butoxydim are seen as the 'last option' to be saved for

emergencies. Once resistance has developed to these two herbicides, the Group herbicides will be useless.

CONCLUSION

Glyphosate resistance in the north eastern cropping zone of Australia is becoming well established due to the over-reliance on glyphosate for fallow weed control, and the failure of growers to monitor weed control to prevent escapes from reproducing. The seed bank of ARG is relatively short-lived, so prevention of seed set for three to five years will run the viable seed to very low levels.

The survey has shown the 'tip of this iceberg', with many more properties that practice 'min-till' weed control likely to be hosting various levels of glyphosate resistant weeds. The trials have demonstrated effective herbicide alternatives to glyphosate in the management of ARG., such as paraquat, Spray.Seed® and mixtures of these with residual herbicides. Timing of application however, is critical, as demonstrated by these two trials.

The presence of glyphosate resistant weeds demonstrates the 'active weed management' is required, and just because you are going 'through the motions', won't prevent the development of herbicide resistance. Mind-sets about the use of strategic cultivation and herbicides such as paraquat need to be addressed if this essential weed management tool, glyphosate, continues to be effective.

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