the northern
HERBICIDE RESISTANCE Reporter

A Newsletter keeping you up to date with research and development in herbicide resistance in the Northern Region

Understanding seed-banks of key weeds

Michael Widderick

A thorough understanding of weed ecology is vital for devising effective weed management strategies. Ecological information on key herbicide resistant and 'at risk' weeds will strengthen herbicide resistance prevention and management strategies and improve weed management overall in the long-term. This is also important to accurately parameterise our model that predicts the evolution of glyphosate resistance in our farming systems.

Increasing wild oat seed numbers for experimental purposes

Currently, the team are undertaking in-depth studies on seed-bank dynamics of wild oat, common sowthistle, and awnless barnyard grasses *(E. colona),* and to a lesser extent liverseed grass and barnyard grass *(E. crus-galli).* We are measuring the impact of different agronomic and environmental factors on the emergence patterns and seed persistence, and options for accelerated seed-bank decline.

Six long-term experiments commenced in 2008 in the same field on the eastern Darling Downs of Queensland:

- **Grass Species – comparing liverseed and the two barnyard grasses in different tillage and cropping systems**
- **Environmental factors – manipulating soil moisture and temperature**
- **Tillage and stubble – timing and intensity of tillage and stubble cover**
- **Cropping systems – winter, summer and continual cropping**
- **Agronomy – fertiliser type, timing and placement, and crop type and competitiveness**
- **Innovative practices – cover crops, organic fertilisers, burning, solarisation.**

In each experiment there is a common treatment of zero-tillage long fallow, which will be used to compare seed-bank decline across the experimental site.

Initially, seed of the target species were sown across the field. Plants were allowed to grow and set large amounts of seed to greatly increase the seed numbers in the soil. Intensive soil sampling is being done on a 6-monthly basis to assess changes in seed-bank resulting from different treatments. In addition, emergences of target species will be measured throughout the experiments. Seedlings will subsequently be controlled to prevent any new replenishment of the seed-bank.

Currently, the second round of soil sampling is underway, and we anticipate that we will start to see some differences in the size of the seed-bank under different treatments. An update on our findings will be presented in future editions of this newsletter.

For further detail on the experiments, please do not hesitate to contact Michael Widderick - Michael.Widderick@deedi.qld.gov.au

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Do you have glyphosate resistance on your farm?

Steve Walker

It is essential that growers and agronomists know whether any weeds in their paddocks or their client's paddocks have developed glyphosate resistance. The following outlines when and how to get weeds tested for glyphosate resistance.

When to test for resistance

Growers should consider having their weeds tested for glyphosate resistance if:

- **(a) their paddocks are at risk for glyphosate resistance, and/or**
- **(b) there are survivors of a glyphosate application.**

Glyphosate resistance has been found in paddocks that have had frequent use and continuous reliance on glyphosate for fallow weed control together with the lack of tillage for the last 10-15 years. Growers can assess their risk for glyphosate resistance by completing a simple questionnaire ***'Check your risk for glyphosate resistance'*** *http://www.dpi.qld.gov.au/cps/rde/dpi/hs.xsl/26_14393_ENA_HTML.htm*

Testing is recommended if you have a 'moderate' or 'high' risk.

Testing is also recommended, if there are survivors of a glyphosate application and if the other common causes of herbicide failure are not likely, such as:

- **Was glyphosate applied in conditions and at a rate that should kill the target weed?**
- **Did the suspect plants avoid herbicide contact or emerge after the spraying?**
- **Does the pattern of surviving plants suggest a spray miss or other application problem?**

Glyphosate resistance appears initially in a few isolated plants. These are healthy and surrounded by dead plants of the same weed species ***(Photo 1).*** In the following seasons, patches of survivors can develop from these isolated plants if they are not prevented from setting seed.

If glyphosate resistance is suspected, then contact your agronomist and one of the researchers listed on the next page for advice. Use one of the testing services listed for determining your resistance status.

Photo 1. Glyphosate resistant barnyard grass

Methods for testing for resistance

The two commercial tests for glyphosate resistance use either ***seeds*** and or ***whole plants.***

The ***seed test*** requires seeds to be collected from the suspect population. Seedlings are grown from these seeds in pots and sprayed with a range of glyphosate rates and their responses are compared with a known susceptible and a known resistant population ***(Photo 2).*** This method is generally very accurate and can test a large range of herbicides and rates if needed. However, the test generally takes 2-3 months to be done *(due to seed dormancy)* and the grower needs to let some suspect plants continue to grow so that seeds can be collected.

The whole plant test is known as the **'Quick-Test'**. It uses ***whole plants*** *(particularly useful for grass weeds)* that are split into several pieces with 2-4 tillers, trimmed and placed in pots ***(Photo 3)***. These are tested in a similar manner to the seed test once the plants are established and growing well. This method has a quick turn-around time for results *(4-6 weeks)* and there is no need to let suspect plants continue to grow to be able to collect seed.

Growers and/or consultants can also conduct their own ***in-situ test,*** which involves applying test strips of glyphosate at a robust rate and a much higher rate to the suspect weeds in the paddock. Indications of glyphosate resistance are the survival of suspected weed species to both glyphosate rates, but other species are controlled by both rates. Resistant weeds sprayed at the higher glyphosate rates may be set back but re-shoot within a short interval.

Collecting samples for testing

Seed or whole plants need to be sampled from a representative area of surviving plants. It is important to record the location of these collection spots with a mud map or GPS.

Photo 2. Barnyard grass plants grown from seed and treated with glyphosate at a range of rates to determine resistance status

For the ***seed test,*** you will need to collect several thousand mature dry seeds *(about 1 cup of seeds for barnyard grass)* from plants within the designated collection area. It is important to gather only physiologically mature seed, not green underdeveloped seed. Mature barnyard grass seed easily fall off the seed heads. Send seed to one of the testing services listed below.

For the ***whole plant test***, you will need to collect a minimum of 50 plants, wash roots free of soil but do not wet the foliage, blot dry, wrap in moistened *(but not wet)* paper towel, place in a water-tight plastic bag and send by express post. See **'Quick-Test'** website for more details - ***www.plantscienceconsulting.com***

Photo 3. The quick test involves testing plants grown from tillers

Where to next?

If the test is negative, but the paddock is considered high risk, then appropriate preventive actions are required. You need to reduce reliance on glyphosate and take actions to stop seed-set on survivors of glyphosate spraying.

If the test is positive for glyphosate resistance, then you will need to develop an IWM plan with your agronomist. Alternate herbicides or non-chemical options are needed to replace glyphosate to control these resistant plants.

Care needs to be taken to prevent further development of glyphosate resistance and prevent spread of resistant seed to other parts of the paddock or other parts of the farm.

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New fleabane research

Steve Walker

GRDC has recently funded a new 3-year research project to investigate options for improved and consistent control of flaxleaf fleabane in the northern region. Another project, based in SA and WA, is also undertaking preliminary research into fleabane control in their farming systems.

Field trial comparing knockdown herbicides applied at different growth stages on fleabane

The NR project is focussing on understanding the impact of important biological and environmental factors on efficacy of key herbicide treatments (knockdown, selective and residual), double knock tactic and promising new herbicides to improve their reliability and effectiveness in crops and fallow, as well as adjacent areas to minimise re-infestations. This information will be promoted in updated brochures and industry presentations, and assist with registration of effective herbicides.

Currently, a range of experiments are underway by the Toowoomba and Tamworth teams:

- **Impact of weed size and soil moisture stress on efficacy of 10 selective wheat herbicides (pot experiment)**
- **Impact of weed size and soil moisture stress on glyphosate efficacy on 11 populations (pot experiment)**
- **Efficacy of 8 herbicide tactics applied to 3 weed ages (field experiment)**
- **Long-term efficacy on 11 residual herbicide tactics for season-long control (field experiment)**

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Management of glyphosate resistant awnless barnyard grass

Tony Cook

Confirmation of glyphosate resistant barnyard grass in northern NSW resulted in a surge of research activity aimed at investigating alternative control options. It served as a grim reminder that the most widely used and effective herbicide, glyphosate, was under threat of becoming obsolete. Furthermore, its discovery has highlighted to other growers that their use of glyphosate should be scrutinised and the principles of integrated weed management must be used in their cropping systems. The following is a summary of this year's research.

Pre-emergence control

A range of herbicides and rates were tested in two replicated experiments. Those that achieved very high levels of control (> 95%) were Dual® Gold at both rates, Flame®, Spinnaker®, Primextra® Gold and high registered rates of atrazine *(Table 1).*

Herbicide	Rate (ha)	% control
Dual® Gold	2L	99
Dual® Gold	1L	98
Flame®	200mL	98
Primextra® Gold	3.2L	97
Spinnaker® WG	140g	97
Atrazine 500	6L	95
Atrazine 500	3.6L	88
Diuron 900	2kg	86
Stomp® Xtra	3.3L	82
Trifluralin 480	1.7L	78

Table 1. Effectiveness of pre-emergence herbicides on barnyard grass, following a light cultivation that disturbed the top 2 to 4cm of soil, stimulating high levels of awnless barnyard grass germination

Selective post-emergence herbicides

Two herbicides from a wide range of selective herbicides tested were highly efficacious. They were Verdict® and Fusilade® when applied at two growth stages *(1 to 4 leaf and early tillering).* However, we strongly recommend that these herbicides should not be relied upon for the majority of weed control as development of Group A herbicide resistance is likely.

Non-selective post-emergence herbicides

Despite glasshouse experiments confirming moderate levels of resistance, applications of glyphosate can be used judiciously to control a high proportion of the population.

Resistance to glyphosate is strongly related to growth stage. Once plants are beyond the early tillering stage, the expression of resistance is evident ***(Photo 1).*** As much as 85 to 95% control can be obtained when glyphosate is applied to 1 to 2 leaf awnless barnyard grass. However, the survivors need to be treated with an alternative herbicide, such as paraquat. This is one example of the double knock technique.

Much effort has been directed at double knocking awnless barnyard grass. Generally levels of control were near 100%, and applications slightly outside the optimum timing window still achieved over 99% control. It is recommended that the first knock *(glyphosate)* be applied no later than the early tillering stage to maximise the efficacy of this herbicide, with an application of paraquat soon afterwards, within seven days of the first knock. Paraquat was consistently and slightly better than Spray.Seed®.

Photo 1. Growth stage affected the expression of glyphosate resistance in barnyard grass. Glyphosate 450 applied at 700mL/ha at 3-4 leaf (L), mid tillering, late tillering and untreated (R)

Control in crop or in fallow?

Summer fallows appears to be best suited for most growers to control awnless barnyard grass. Some reasons (cultural and chemical) why a seed bank depletion strategy should be based on fallows include;

- The ability to use the widest range of herbicides without immediate crop damage implications
- Using blanket applications of knockdown herbicides
- No protection from crop sowing lines or shielding from herbicides due to crop canopy
- Cultivation over the entire paddock *(Photo 2)*
- Easier to inspect fallows for low weed densities
- Crops utilise moisture allowing surviving weeds to stress faster than what would happen in fallows. This would lead to poorer control with herbicides.

An integrated approach

As mentioned previously, experience suggests that a shallow disturbance to the seed bank will encourage awnless barnyard grass to germinate, accelerating seed-bank decline (if these seedlings are fully controlled). Other potentially useful strategies may include the use of summer-active green manure crops, provided that effective pre-emergence herbicide can be used. Strategic cultivation could be considered, particularly if plants develop into large tillered plants, as often happens when growth is rapid in summer. At this stage, most herbicide options do not give full control and the use of cultivation may be the only one that will completely prevent seed set. Using stock to graze this weed is not recommended, as grazing pressures are usually not high enough to achieve high levels of control. Furthermore, it is likely that using stock will spread resistant plants to other paddocks by passing viable seed through the digestive tract or seed adhering to muddy hooves.

Photo 2. This plant was protected from cultivation in the intra-row area and is capable of substantial replenishment of the seed bank

Conclusion

The partial loss of glyphosate is a serious threat to agriculture. The promotion of an integrated management approach is required to take selection pressure off the remaining chemical options. A balanced approach that relies upon cultural and existing herbicidal options is recommended.

Australian Glyphosate Sustainability Working Group

Steve Walker

The group, which consists of researchers, communication specialists, and representatives of grain, cotton, horticulture and chemical industries, met for their annual meeting recently in SA. This was preceded by the group visiting field experiments on glyphosate resistant ryegrass growing along a fence line, and discussions with several owners of vineyards on how they developed and are now trying to manage their glyphosate resistant weeds - (see photo).

This year has seen some major changes with the group, with a new name, logo and website. The group has also expanded to include representatives from other agricultural industries. In the near future there will be updated and new brochures on preventing glyphosate resistance in the following situations: grains, cotton, sugarcane, horticulture, vineyards, roadsides and public amenities.

Currently, there are confirmed populations of glyphosate resistant annual ryegrass in 45 broadacre cropping paddocks; 19 tree and vine crops; 25 fence lines, driveways and firebreaks; and 11 in irrigation channels, airstrips, railway and roadsides.

As well, there are 2 cases of glyphosate resistant liverseed grass and 5 barnyard grass populations in the northern region.

Glyphosate resistant annual ryegrass at a fence line surviving very high glyphosate rates

For more information, please go to the NEW website www.glyphosateresistance.org.au

Residual herbicides for the management of feathertop rhodes grass

Vicki Osten

In previous editions we have discussed the positive virtues of the double-knock technique (glyphosate followed by paraquat) for the control of summer grasses in fallow. This tactic effectively works on feathertop Rhodes grass *(Chloris virgata)* or FTR as well, provided the plants are pre-tillering to early tillering stage when treated. Once FTR reaches mid-tillering it is often difficult to control with glyphosate.

Growers can value-add to the double knock by adding a residual herbicide to the second knock to create a triple knock, thereby adding a further alternative herbicide group to target the weed. This is very important for reducing the risks for glyphosate resistance development.

Residual control of FTR can range from 2 to 7 months, depending on the residual herbicide and rate chosen, the time of year applied and the ensuing rainfall.

Research in central Queensland has shown that Flame®, Atrazine, a mix of Atrazine and Dual®Gold, Trifluralin and Glean® have good long-term residual activity on FTR when applied with a knockdown in summer fallows (Table 1). While Dual Gold and Glean are not registered for fallow use, these positive results have application in-crop (sorghum and wheat). In contrast, only short-term control was achieved with the Group A herbicides Verdict and Fusilade, as well as Ally and Express.

All treatments were applied at relatively high water volume (84 L/ha). For both trial sites, soil moisture condition was excellent at the times of spraying and good follow-up rain occurred during the 2-3 month period (220-250mm total rain). Conditions over the period were warm to hot (32-38°C). Both sites had slightly alkaline soils but differing clay types and contents with site 1 having less clay than site 2.

Should the residual be added with the first knock or the second knock? The answer depends on the density of the target weed. As a general rule, if the grass is providing more than 50% ground cover at the time of the first knock, then it is often better to apply the residual with the second knock. Residual herbicides need to reach the soil where they can be activated and therefore effective. On the other hand, applied in the first knock in low weed density situations allows the residual to act upon those weeds still germinating but not yet emerged particularly if soils are moist at the time of application.

Excellent long-term control of FTR with triple knock of glyphosate followed by Gramoxone® + (Atrazine + Dual®Gold) at Comet at 60 DAT during which 220mm rain was received

	Herbicide treatments (rate per ha)			Weed control ratings (0 = no control, 5 = 100% control)			
				Site 1		Site 2	
	Knockdown	Knockdown	Residual	30 DAT	60 DAT	44 DAT	92 DAT
1	Glyphosate CT 2L	Gramoxone® 1.6L	Atrazine 2.5L + Dual®Gold 2L	5	5	5	4.8
2	Glyphosate CT 2L	Gramoxone 1.6L	Flame® 200mL	1.9	4	5	4.3
3		Gramoxone 2L	Trifluralin 1.7L	2	4.5	5	4.2
4		Gramoxone 2L	Atrazine 3.0L	3.5	3.3	4.9	4.5
5		Gramoxone 2L	Atrazine 2.5L + Dual Gold 2L	5	5	5	5
6		Gramoxone 2L	Atrazine 5.0L	4.4	3.8	5	3.7
7		Gramoxone 2L	Flame 200mL	3.7	4.7	4.7	4.7
8		Glyphosate CT 2L	Flame 200mL	-	-	5	4
9		Glyphosate CT 2L	Ally® 7g	1.4	2.8	4.4	0
10		Glyphosate CT 2L	Glean® 20g	3.5	3.8	4.8	3
11		Glyphosate CT 2L	Express	2.5	2.5	4.8	0
12		Select® 375mL		2	0	4.9	0
13		Verdict®520 600mL		4.8	3.8	4.9	0
14		Fusilade® 2 L		5	3	3.9	2.3
	LSD (P = 0.05)			**0.9**	**1.1**	**0.7**	**1.1**

Table 1. Long-term weed control of FTR achieved with double knock with pre-emergent herbicides (treatments 1, 2), knockdown mixed with pre-emergent herbicides (treatments 3 – 11) and Group A herbicides (treatments 12 – 14) in fallow at Comet (site 1) and Dysart (site 2). DAT = days after treatment application

Time of year when applied also influences the length of residual activity. Herbicides like Flame®, Atrazine and Dual®Gold have provided longer residual control (up to 4 months longer) when applied in the cooler parts of the year (data not presented) compared to late spring/summer applications. Our research has also shown that these residuals (including atrazine) will break down more quickly during summer if conditions remain wet in the 2-3 month period after application.

Residual herbicides are worth considering for the management of a difficult to control weed like FTR since the grass has the ability to germinate all year round. Limited seed biology research is also indicating that FTR seed may be short-lived in the soil (~ 12 months), so using a residual allows several cohorts to be hit with the one application.

FTR also produces peak flushes when more than 50mm of rain is received over 3-4 days, and it is ideal to have a residual herbicide applied before these peak flushes occur. A peak flush can also be stimulated by a light shallow tillage operation, which can also be utilised for residual herbicide incorporation, particularly for herbicides such as atrazine or trifluralin.

Of course when using any residual herbicide, re-cropping flexibility may be reduced and this can be an issue in opportunistic cropping systems.

Controlling survivors

Jeff Werth

Strategies for the prevention and/or management of herbicide resistance involve Integrated Weed Management (IWM) i.e. rotation of weed control methods (chemical, mechanical and cultural) and rotation of herbicide mode of action groups.

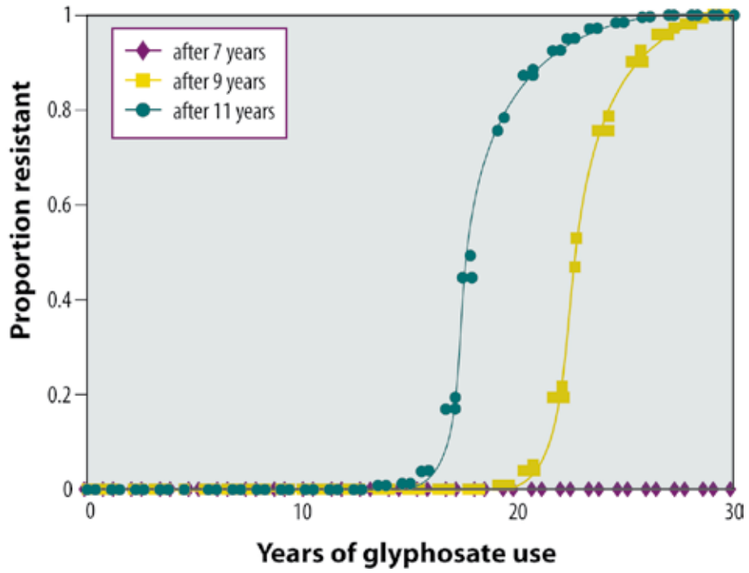
Another part of the IWM strategy is controlling survivors of herbicide application. This has been adopted in the Roundup Ready® and Liberty Link® crop management plans for cotton and canola, as an important tool for resistance prevention.

Consider a field that is full of species 'X'. The field is sprayed with a herbicide and 95% are killed. This is considered a good result. However, what about the 5% of species 'X' that survived. We don't know whether they survived because they are resistant to the herbicide or there were other factors involved. However, if we now go and control those survivors to prevent them setting seed, they are not an issue anymore and will not add to the seed bank. This tactic is especially important where it is known that there are resistant weeds.

David Thornby has done simulations with his model to predict development of glyphosate resistance in awnless barnyard grass in continuous summer fallows where glyphosate is the only herbicide applied (Figure 1). The green circle indicates where survivors had not been controlled for the first 11 years of this zero till practice, but were then controlled every year since. When survivors are controlled two years earlier after 9 years (yellow square) the time for resistance development is delayed by 2-3 years. However when survivors are controlled after 7 years (purple diamond) resistance does not develop. This shows how important controlling survivors can be and how important it is to start sooner rather than later.

Keeping IWM in mind, it is also important the survivors of herbicide application are controlled by either a different method or at least from a different herbicide mode of action group. It is usually not known if they are resistant, so using the same herbicide could just make the problem worse.

Figure 1. Effect of controlling survivors of glyphosate applications in continuous summer fallows where glyphosate was the only herbicide used



Glyphosate resistant liverseed grass - another new threat!

Tony Cook

Yet another weed species has developed glyphosate resistance. Less than two years ago, two populations of Liverseed grass – also called Urochloa grass – were confirmed as having low levels of glyphosate resistance. Interestingly, the Northern Herbicide Resistance Reporter team identified this species as a high risk candidate for developing glyphosate resistance in 2006.

These populations are located in northern NSW. The primary reasons for this new discovery are the dependency on no-till farming systems, over-reliance on glyphosate and a dominance of winter cropping.

Confirmation of resistance

Two pot experiments confirmed the presence of resistance; one experiment from Plant Science Consulting in SA (herbicide resistance testing service) and the other from Industry and Investment NSW staff (formerly NSW DPI). The results presented here indicate a moderate to low level of resistance (see photo). Under the ideal growing conditions in the second pot experiment, the resistant population survived a low rate of glyphosate which killed the susceptible plants *(Table 1)*. This will be investigated further this season.

Table 1. Confirmation of glyphosate resistant Liverseed grass

	Susceptible		Resistant	
Glyphosate 450 rate (ml/ha)	Control rating (0 – 5)	Biomass reduction (%)	Control rating (0 – 5)	Biomass reduction (%)
0	0	0	0	7
350	4.9	99	4.2	91
700	4.9	99	4.9	99
1050	5.0	100	5.0	100

Highlighted cells indicate improved survival.

If you suspect that Liverseed grass is resistant to glyphosate, information regarding all aspects of herbicide resistant testing can be obtained from ***http://www.plantscienceconsulting.com/***

Susceptible (left) and resistant (right) liverseed grass plants following treatment with Roundup Powermax at 500mL/ha. Picture courtesy of Plant Science Consulting

Implications

The presence of glyphosate resistant Liverseed grass will require some changes to weed control tactics. This development is an indicator of weed management practices where continuous reliance upon glyphosate has been the only method of grass control in summer fallows.

Therefore, the simple option of continual use of glyphosate in summer fallows needs to change. This is particularly necessary in those regions that are limited to winter cropping.

In summer cropping regions, growing a summer crop reduces the number of glyphosate applications on liverseed grass and therefore may prolong the usefulness of glyphosate. However, this requires the use of highly effective residual and selective herbicides, an area that requires more research.

Similarly, the bulk of previous research on fallow Liverseed grass management was limited to glyphosate, and a thorough investigation is required on all aspects of Liverseed grass management. Firstly, all chemical options need to be examined, similar to what has been done for glyphosate resistant annual ryegrass and awnless barnyard grass. This requires validating what effective herbicides are available for pre- and post-emergence applications for fallow and in-crop and using the double knock strategy. More information is also needed on the ecology of this grass, particularly relating to emergence patterns and seed persistence in the soil seed-bank.

On a positive note, it seems that glyphosate resistant Liverseed grass can be managed. Despite the lack of information regarding effective options, a farmer that has the problem has significantly reduced his infestations in one year. The key to this achievement was not allowing the weed to set seed. This basic philosophy is a cornerstone to all herbicide resistance management strategies.

Effective control of summer grasses with a triple knock

Michael Widderick and Jeff Werth

Summer grasses are prevalent and troublesome throughout much of the northern grain region. In addition, they are at high risk of developing glyphosate resistance as there are few other products used for their control. There is a continued need to identify options that both reduce the risk of glyphosate resistance while improving weed control in the long-term.

In two field experiments near Dalby, Queensland, the efficacy of the double and triple knock tactics was evaluated on glyphosate susceptible awnless barnyard grass, liverseed grass and feathertop Rhodes grass.

A double knock, typically glyphosate followed by paraquat some 7 days later, has been shown to be effective for the knockdown of summer grasses. The addition of a residual herbicide (third knock), as a mix partner in either the first or second knock, has potential to improve long-term control of the target grasses by reducing subsequent flushes of emergence and thereby the need for subsequent knockdown herbicides.

Results from the two field trials are summarised in *Table 1*. Some points to note are:

- Control of barnyard grass and feather top Rhodes grass was reduced dramatically by deferring glyphosate application by only 1 week.
- RoundupCT® followed by paraquat gave 99% control on all species. This is a great result, but there was still room for the odd survivor which requires remedial action.
- RoundupCT® mixed with Nutrazine® resulted in poor control of barnyard grass
- Feathertop Rhodes grass was less susceptible to paraquat than the other species.
- Rainfall after application of the second knock of 62mm resulted in an average of 44, 44 and 12 new barnyard FTR and liverseed grass seedlings per m^2.
- The addition of residual herbicides greatly reduced these new flushes, with Dual®Gold (metolachlor) performing the best, followed by Flame® (imazapic).
- Paraquat mixed with Nutrazine® did not prevent emergence of barnyard grass and feathertop Rhodes grass.

Using residuals in fallow increases weed management costs. However if conditions are favourable, they could minimise future germinations and save one or two broadacre sprays with just some scouting and remedial action required. Applying double knock with the aim to prevent seed set, particularly in problem fields will have long-term benefits and prolong the effectiveness of glyphosate. The costs if glyphosate resistance occurs will be much greater than taking preventive measures now.

Table 1. Effectiveness of double knock applied with or without residual herbicides on summer grasses in fallow

Knock 1 ± Residual	Knock 2 ± Residual (applied 7 days after Knock 1)	Control (%) (measured at 14 days after Knock 1)			New emergences (m^2) (measured at 50 days after Knock 1)		
		BG	LG	FTR	BG	LG	FTR
RoundupCT®		**99**	**98**	**99**	**26**		
	RoundupCT	52	99	80	74		
RoundupCT	**Paraquat**	**99**	**99**	**99**	**27**	**14**	**35**
RoundupCT	Paraquat (2.4L)	99	99	99	50	9	52
RoundupCT + Nutrazine 900® + AMS		**63**	**99**	**94**	**17**	**6**	**29**
RoundupCT + Flame®		99	99	99	16	3	6
Paraquat + Nutrazine 900		**99**	**99**	**90**	**33**	**2**	**49**
Paraquat + Flame		97	99	87	16	1	5
RoundupCT	**Paraquat + Nutrazine 900**	**99**	**99**	**99**	**7**	**19**	**18**
RoundupCT	Paraquat + Dual Gold	99	100	99	1	1	2
RoundupCT	**Paraquat + Flame**	**99**	**99**	**99**	**8**	**2**	**14**
RoundupCT	Paraquat + Primextra Gold	99	99	99	3	5	9
RoundupCT + Nutrazine 900 + AMS	**Paraquat**	**92**	**99**	**97**	**11**	**4**	**24**
RoundupCT + Dual®Gold	Paraquat	99	100	100	1	7	3
RoundupCT + Flame	**Paraquat**	**99**	**100**	**99**	**10**	**1**	**3**
RoundupCT + Primextra®Gold	Paraquat	95	99	98	0	4	3

Initial populations (plants/m2) were barnyard grass (BG) 670; liverseed grass (LG) 204; feathertop Rhodes grass (FTR) 645. Application rates (L/ha) were Roundup CT® 1.6, Paraquat 1.6 except where noted, Nutrazine® 900 2.5, Flame® 0.2, Dual®Gold 2.0, Primextra®Gold 3.2. Note that Nutrazine is not registered on Liverseed grass, and Dual Gold, Primextra Gold, Nutrazine and Flame are not registered on Feathertop Rhodes grass.

Herbicide resistance risk assessment for farming systems with cotton

Jeff Werth

The recent finding of barnyard grass and liverseed grass populations that are glyphosate resistant has made us question what other species could also become resistance issues in our cropping systems.

To try and answer this question, QPIF has undertaken a resistance risk assessment to identify weeds that need to be watched. This has been broken up into two parts:

1) a desktop assessment of weed species' biological characteristics that are important for resistance, and

2) field surveys of previously surveyed fields for changes to the weed spectrum in the past 8 years.

Barnyard and liverseed grass infest a cotton field trial

Biological Characteristics

The biological characteristics that are considered important for resistance development were condensed down to 5 main factors (in order of importance):

- **Fecundity – the number of seeds the species produces**
- **Proportion of the viable seed bank emerging – this takes into account dormancy characteristics and emergence patterns**
- **Generation period – the ability of the species to produce multiple generations within a season/year**
- **Reproduction method – vegetative, sexual or both**
- **Mating characteristics – whether the species mainly outcrosses or self-pollinates**

Table 1. Ranking (using a 1 to 10 scale) of weed species for their resistance risk due to biological characteristics. Bolded species indicate those commonly found in recent surveys in SQ and northern NSW

Species	Resistance risk rating	Current glyphosate resistance status
Sweet summer grass	8.1	None
Flaxleaf fleabane	7.6	USA, South Africa, South America
Liverseed grass	7.2	2 populations in NSW
Feathertop Rhodes grass	7.0	None
Sowthistle	6.6	None
Awnless barnyard grass	6.6	3 populations in NSW, 2 in QLD
Crowsfoot grass	6.3	Malaysia, Columbia
Button grass	5.9	None
Summer grass	5.9	None
Redshank	4.8	None

Over 60 species were considered in this assessment, including species found in the surveys and those found on glyphosate labels. *Table 1* shows the species that rated in the top 10. Notice the majority of these weeds are grasses, this is primarily due to their ability to produce large numbers of seed. The species listed are good ones to keep an eye on.

Field Surveys

The QPIF conducted a weed survey in 2001 on dryland cotton farms in order to determine what weed species were present and to identify weed management issues. Recently, these farms were revisited along with additional fields monitored by NSW DPI to see what changes had occurred since then. The major change was the increase in the presence of flaxleaf fleabane, which didn't make the top 12 in 2001 and now is equal second with sowthistle in prevalence.

We will survey these fields again next year to cover other parts of the crop rotation and any possible climate differences. The next stage for the risk assessment is to incorporate management practices.

This information will provide a background into a web based Risk Assessment Tool (RAT).

Workshops for cotton growers

Susan Maas

The Qld Primary Industries and Fisheries Weeds team have responded to increasing concerns within the cotton industry relating to herbicide resistance by creating a package that builds awareness about the risks of current practices. In recent years the cotton industry has significantly increased its reliance on glyphosate through the high adoption of Round up Ready Flex® technology. In 2008, 70% of Australian cotton was Round up Ready Flex®. While this change in practice has brought about many benefits to growers, it has substantially increased the risk of herbicide resistance developing.

To help manage this issue, the Weeds Team and Australian Cotton CRC extension team have developed a herbicide resistance workshop and risk assessment tool for the cotton industry. The focus is to improve an individual's knowledge about risk factors and management strategies that can be implemented address local weed management issues. Tailored for each region, the workshops will be rolled out by the Cotton CRC extension team later this year.

In addition to the workshop, the Weeds Team is also developing a Risk Assessment Tool (RAT). Complementary to the workshop, this web based tool uses the grower's current rotations and practices to calculate a glyphosate resistance score as well as identifying parts of the rotation at risk, and weeds most likely to develop resistance.

Specific dates and locations of workshops will be announced once details are finalised. For more information or to register your interest, please contact Susan Maas (07) 4983 7403 (Development extension officer, QPIF Emerald).

The RAT (Resistance Assessment Tool)

David Thornby

A new package of online tools is under development by QPIF weed scientists. These tools, designed to integrate with herbicide resistance action learning workshops, will provide growers with two ways to assess and manage their glyphosate resistance risk.

Using the Test Your Knowledge tool, growers can assess their current level of knowledge about resistance issues, and get advice on the areas in which they need to know more.

Using the Risk Assessment Tool, growers can assess how risky their current weed control and cropping practices are, from the point of view of glyphosate resistance. The risk assessment tool will identify risky practices that could be changed, and can identify both weed species and parts of the crop rotation that are most at risk.

Risk management is a critical part of the decision-making process for growers and land managers. As the number of glyphosate-resistant weed populations in northern Australian grows, the importance of good decision-making around weed control and herbicide use also increases. Assessing and dealing with the risk of developing a resistance problem could help growers increase the useful lifespan of glyphosate on their farm by many years, and may even help prevent a costly resistance problem developing.

Australian cotton growers, and in particular those who have grown or are considering growing glyphosate tolerant cotton varieties, face particular risks for the evolution of glyphosate resistant summer weeds. A decade after the introduction of glyphosate tolerant cotton varieties, it is now a critical time to assess the resistance risk for those who have taken advantage of the technology, or may wish to do so in the near future. While risk assessment is a key part of the BMP Cotton process, all growers can benefit from assessing the risk level of their farm and their past weed control actions.

Once the tools are online, growers will be able to assess their knowledge and the risk level of individual paddocks by answering a series of questions and providing details of their crop rotation and typical weed control practices, at a time and place that suits them. Growers who have signed up to attend a resistance workshop will be asked to complete both online tools, and their confidential responses will be pooled with other workshop attendees. The workshop facilitator can then use the group's responses to tailor the workshop to suit the needs of the group, emphasising information that is most needed.

The preliminary online resistance assessment toolset is expected to be released in the next few months on the QPIF website. Development of the risk assessment toolset is supported by the GRDC, CRDC, Cotton Catchment Communities CRC and Monsanto.

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