Weed detecting technology: an excellent opportunity for advanced glyphosate resistance management

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Summary Glyphosate resistant weeds are emerging as a high priority issue for cropping areas throughout Australia. The most suitable situation to manage glyphosate resistant weeds is in the fallow phase. Weed detection technologies enable farmers the opportunity to manage these weeds in fallows.

Other key benefits of using weed sensing boom sprays include; reduction in herbicide use/costs, greater choice of modes-of-action, justification to use more of expensive herbicides, ability to increase dose rates and capacity to control light scattered infestations.

Keywords Glyphosate, resistance, fallow, management, WeedSeeker, double knock.

INTRODUCTION

In the management of glyphosate resistant weeds, fallow is the most opportune time to reduce populations to extremely low levels. Under fallow conditions farmers can opt for many effective tactics. These may include: cultivation to kill plants or to invert seed banks; use of pre-emergence herbicides; double knocking; stubble and windrow burning grazing; and application of post-emergence herbicides.

In the northern grain region, fallow management is dominated by post-emergence herbicide spraying. The herbicide of choice is glyphosate, although with the steady increase of glyphosate resistance, people are employing the double knock tactic. This has proven to be very effective though it is considered to be time consuming and expensive.

Other strategies such as grazing, soil inversion and stubble burning are not suited to northern grain cropping systems and have inherent risks for soil structure decline and erosion. Pre-emergence herbicides are seldom used in fallows as growers find the effectiveness of glyphosate to be more reliable and it does not limit crop sequence. As a last resort, some farmers have resorted to cultivation to control large glyphosate resistant plants as there are no herbicides registered for control of advanced plants.

Another common issue with glyphosate resistance management is the control of extremely light infestations. Often farmers battle large or dense infestations successfully but are unable to control populations nearing the eradication phase. These plants generally survive to set seed enabling continuation of the problem. Some farmers have persisted by hand weeding or spot treating. Undertaking a manual spot control strategy may be feasible on smaller properties, but is likely to become more problematic as property size increases.

Introduction of the weed detector boom sprayer has created many opportunities for enhanced management of glyphosate resistant weeds. Its role with other tactics is described along with its application for controlling other hard to kill fallow species.

NEW PESTICIDE PERMIT

Despite being used extensively in many states, weed detector boom sprayers were not recognised by the Australian Pesticides and Veterinary Medicines Authority (APVMA) as a registered use pattern. As recently as 2011, the APVMA granted a minor use Permit for people in NSW to use WeedSeeker® technology. In 2012, the Permit was revised allowing all users in Australia to use WeedSeeker® technology in fallows.

The permit enables access to a wider range of herbicides and rates in fallow paddocks when using WeedSeeker® spray equipment and spraying less than 30 per cent of the paddock area.

A total of 30 different herbicides is listed on the permit, some being non-residual and others with short or longer term activity in the soil. Seven different herbicide mode-of-action groups are represented, enabling growers to effectively rotate their chemistry (Table 1).

Furthermore, previous investigations by NSW DPI staff have found herbicides such as paraquat or Group A herbicides to be extremely useful options to control glyphosate resistant grasses (Davidson and Cook 2010). There is moderate to high risk of plants developing resistance to the herbicide. However, the permit has ample guidance about minimising this.

The new permit allows the use of many herbicides and at robust rates. Some herbicide rates have been increased to allow for control of larger, stressed or harder to control weeds. For example the glyphosate 450 g L^{-1} rates range from 3 to 4 L ha^{-1} (using a set water rate of 100 L ha^{-1}), which exceeds the label blanket rate of 0.4 to 2.4 L ha^{-1}. Likewise, similar increases in rate are allowed for paraquat or paraquat/diquat herbicides.

There is allowance for herbicides to be tank mixed, if permitted on either product's label. In addition, the more affordable tank mix herbicide (e.g. glyphosate or pre-emergence herbicide) could be co-applied *via* a separate conventional boom spray.

All users of this Permit must comply with the calibration instructions contained within the Permit. It is of utmost importance to follow these instructions since operating outside these guidelines is likely to result in inaccurate delivery of herbicides and sub-standard results. As such, the Permit limits the boom height to 75 cm, using 65 degree flat fan even-jet nozzles that apply a water rate of 100 L ha^{-1}. There is some scope to increase the nozzle aperture, adjust spray pressure and ground speed provided the water volume remains at 100 L ha^{-1}.

Regular reviews and changes to the Permit will ensure it is a dynamic document. It is envisaged that chemical companies will seek label registrations for weed detector use patterns for their specific products, thereby negating the need for some herbicides on the Permit. However, it is likely that other new or existing herbicides will be included with time as research identifies a need for them in fallow weed control.

Table 1. Herbicides registered for use with WeedSeeker® applicator for weeds up to 10% (marked with #) or 30% coverage.

Herbicide(s)	Group	Product rate ha^{-1}
glyphosate (450g L^{-1})*	M	3 – 4 L
paraquat (250g L^{-1})	L	3 – 4 L
paraquat + diquat (135g + 115g L^{-1})	L	3 – 4 L
glufosinate (200g L^{-1})	N	5 L
amitrole + paraquat (250g + 125g L^{-1})	Q + L	10 L
amitrole (250g L^{-1})	Q	10 L
2,4-D amine (625g L^{-1})*	I	3 – 4 L
2,4-D ester (680g L^{-1})	I	2.7 – 3 L
triclopyr ester (600g L^{-1})	I	160 – 300 mL
fluroxypyr (200g L^{-1})*	I	1.5-3.0 L
quizalofop (200g L^{-1})	A	250 – 500 mL
haloxyfop (520g L^{-1})	A	200 – 800 mL
sethoxydim (186g L^{-1})	A	1 L
clethodim (240g L^{-1})	A	500 mL
butroxydim (250g L^{-1})	A	100 – 200 g
fluazifop (212g L^{-1})	A	1 – 2 L
2,4-D + picloram (300g + 75g L^{-1})#	I	1 L
clopyralid (300g L^{-1})#	I	250 – 500 mL
clopyralid (750g kg^{-1}) #	I	100 – 200 g
aminopyralid + picloram + triclopyr (8g + 100g + 300g L^{-1})#	I	1 L
picloram + triclopyr (100g + 300g L^{-1})#	I	1 L
metsulfuron (600g kg^{-1})#	B	5 – 10 g
fluroxypyr + aminopyralid (140g + 10g L^{-1})#	I	1 L

Note: * denotes other products on permit with different concentrations of that active ingredient. Refer to permit for specific rates.

Access to the Permit is *via* the APVMA website (www.apvma.gov.au) and the permit number is 11163. It expires on February 28 2015; however there are provisions to allow this Permit to be renewed.

BENEFITS FOR INDUSTRY

Options for more flexible weed control can now be explored and used legally. There is likely to be an accelerated research push for novel ways of using the technology. Some of the benefits to industry include:

Increased rates for certain herbicides, enabling better control of larger or moisture stressed weeds.

Allowing a broader range of herbicide modes-of-action for use in fallows; for example, the ability to use Group A herbicides or glufosinate.

Reduction in total herbicide used. Evidence indicates that reductions in herbicide usage can be as much as 90% (Brownhill 2007, Osten 2009).

Substantial reductions in herbicide drift. Guidelines for operating WeedSeeker® boom sprays requires a minimum of 03 nozzles with coarse droplet ratings and higher water rates (100L ha^{-1}) than commercial blanket boom spray standards. As this technology is limited to fallows with no greater than 30% weed cover, nozzles will be turned off for the majority of time further reducing potential for drift.

Resistance management is significantly improved. By allowing the use of more herbicide modes-of-action farmers can rotate the herbicide groups.

Sustaining conservation tillage by maintaining weed control via herbicide control tactics and reducing the reliance on cultivation. Thus the benefits of moisture conservation and soil structure will be maintained.

Keeping weed numbers at extremely low densities. This is a key principle of resistance management and may provide for patch eradication on a smaller scale.

Potential areas of research There is in the northern grains regions a range of scenarios that would benefit from weed detection technology.

An ideal fit would be the application of double knock treatments. Costs associated with double knock are high and reductions in expenditure would be beneficial. This tactic is commonly employed to prevent or manage glyphosate resistance, usually on small, patchy infestations.

Weed detection technology has a role after the application of pre-emergence herbicides. Residual herbicides, when used correctly and where suitable rainfall follows soon after application, provide excellent control. They are promoted as a first line of control for glyphosate resistance management. However, a small to moderate proportion of individuals ultimately survive. In these low density situations weed detection devices are ideally suited.

Larger or moisture stressed weeds can be targeted with higher than standard rates of herbicides. Tolerance of herbicides is often due to these parameters with higher dose rates required for larger weeds (Cook 2009). Investigations into the use of Group A herbicides for glyphosate resistant grass management is a high priority. Preliminary findings by Davidson and Cook (2010) show these herbicides to be very effective on large awnless barnyard grass plants as a single application. However, such applications need to occur in conjunction with post-treatment knocks (bipyridyls) to ensure kill of potential Group A resistant plants.

More expensive herbicides have a role with spot treatment boom sprays. Some herbicides are priced for horticultural use patterns, inhibiting their development for broadacre grain growing regions. As only a small proportion of the paddock is sprayed, the economics of employing more expensive herbicides is improved.

It is feasible that GPS technology could be partnered with weed detector apparatus to map the weeds as they are sprayed. This information could be crucial for planning weed management and directing treatments more judiciously. For instance, applying a patch of pre-emergence herbicide over known weed hot spots could save pre-emergence herbicide costs. A key success for resistance management is the early detection of small patches and their subsequent treatment.

DISCUSSION

Although weed detector technology has been used in the grain growing industry for several years, the presence of glyphosate resistant fallow weeds has expedited the need for this technology.

Their costs saving benefits have long been promoted. However there now appears to be greater value in their use than originally envisaged.

The granting of a new national Pesticide Permit is a promising fillip for this technology. There is interest from some chemical companies to incorporate weed detector applications on their labels. With the issue of a Pesticide Permit and potential label registrations, agronomists and researchers will have greater freedom to advise their client base of this technology as this overcomes restrictions on advice to end users of unregistered treatments.

Overall, the grains and cotton industries are substantial beneficiaries of this innovation and it is likely that its application in other agricultural enterprises can deliver benefits, particularly with respect to glyphosate-resistant weed management.

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