Glyphosate resistance management

By Dr James Neilsen and Craig McDonald, Monsanto Australia

Herbicide resistance is an induced inherent ability of some plant species to survive and reproduce after receiving a lethal dose of herbicide. Globally herbicide resistance has been confirmed in 187 weed species across more than 300,000 paddocks in a range of modes of action (Figure 1). In Australia, herbicides are classed according to groups based on their mode of action. Herbicide resistance has been confirmed in 11 of the 19 mode of action groups.

Resistance is a costly problem — if resistance develops, growers have to use alternate control measures or herbicides, and these can be more expensive and/or less effective. In some cases, growers will not be able to grow certain crops, or may have to change their farming system to include more tillage.

Understanding if weeds are resistant to a particular herbicide is not clear cut. Some weeds are tolerant to the application of a specific herbicide, but this does not necessarily mean that they are resistant weeds. To declare a weed to be resistant, the international survey of resistant weeds has stated that it must fulfill five criteria:

- Fulfilment of the Weed Science Society of America definition of resistance and the survey's definition of a herbicide-resistant weed;
- Data confirmation using acceptable scientific protocols;
- The resistance must be heritable;
- Demonstration of practical field impact; and,
- Be a weed identified to species level and not be the result of deliberate/artificial selection.

When is a weed resistant? Identifying herbicide resistant weeds and reducing the potential for development of resistance in glyphosate tolerant crops.

The use of these criteria in the deceleration of herbicide resistance provides a uniform definition of cases, so that any development of resistance can be tracked.

Glyphosate resistance

Glyphosate, the active ingredient in Roundup herbicides is a Group M herbicide (inhibits the production of EPSP synthase). Since its commercial introduction over 30 years ago, glyphosate has become the most used herbicide worldwide. This is due to its highly effective broad-spectrum efficacy and its high level of environmental safety.

The chemical properties of glyphosate and three decades of commercial experience demonstrate a low level of resistance development. Glyphosate resistance has been confirmed in biotypes of 13 weed species globally.

In Australia weed resistance to glyphosate is rare but does exist in a number of annual ryegrass (*Lolium rigidum*), barnyard grass (*Echinochloa colona*) and liverseed grass (*Urochloa panicoides*) populations. In fact Australia was the first country to confirm resistance to glyphosate with resistant annual ryegrass discovered in 1996.

The national glyphosate sustainability working group *(www.weedscrc.org.au/glyphosate)* lists a number of factors that are implicated with glyphosate resistance:

- Continuous reliance on glyphosate pre-seeding;
- Lack of tillage;
- Lack of effective in-crop weed control;
- Frequent glyphosate-based chemical fallow;
- Inter-row glyphosate use (unregistered);
- Frequent crop topping with glyphosate; and,
- High weed numbers.

These common factors show that with a proper integrated weed management approach the risks of glyphosate resistance can be managed. Using other mode of action groups in the crop rotation, ensuring good spray application with a high level of weed control and using robust rates will all reduce the chance of resistance developing.

All weed populations contain individual plants that are resistant to herbicides. Repeated use of any herbicide will expose weed populations to selection pressure, allowing resistant plants to survive and increase (Figure 2). It is important to remember that it is the use pattern imposed on glyphosate, and not glyphosate itself that is the issue. The issue is fundamentally a break-down in a farming system, an over reliance on one weed control tool.

Glyphosate resistant crops

With the introduction of glyphosate resistant crops in to the Australian cropping system (cotton in 2000 and canola in 2008) there has been an increased focus on the sustainability of glyphosate in the cropping system. Monsanto has developed resistance management plans for cotton and canola to steward both the technology and the herbicide to ensure they remain effective tools in the cropping system. These management plans have been studied by external scientists to ensure the rigour on

...16 ▷

Roundup Ready Flex cotton has dramatically reduced the need for chipping.

the science. For example, Werth et al. (2008) reported the findings from a simulation model designed to determine the risk of glyphosate development in glyphosate resistant cotton.

This work supports the resistance management strategies already in place in preventing seed set from survivors of glyphosate applications by using alternative weed control options. They also commented that one of the important benefits of the crop management plan is the accreditation course, through which growers are educated on the principles of resistance management and the importance of implementing an integrated weed management strategy.

In Roundup Ready and Roundup Ready Flex cotton, growers are able to apply Roundup Ready herbicide over the top to provide broad spectrum weed control. It is recommended that an integrated weed management strategy be implemented to ensure the system is not reliant on glyphosate alone to ensure the ongoing sustainability of the herbicide tolerant technologies.

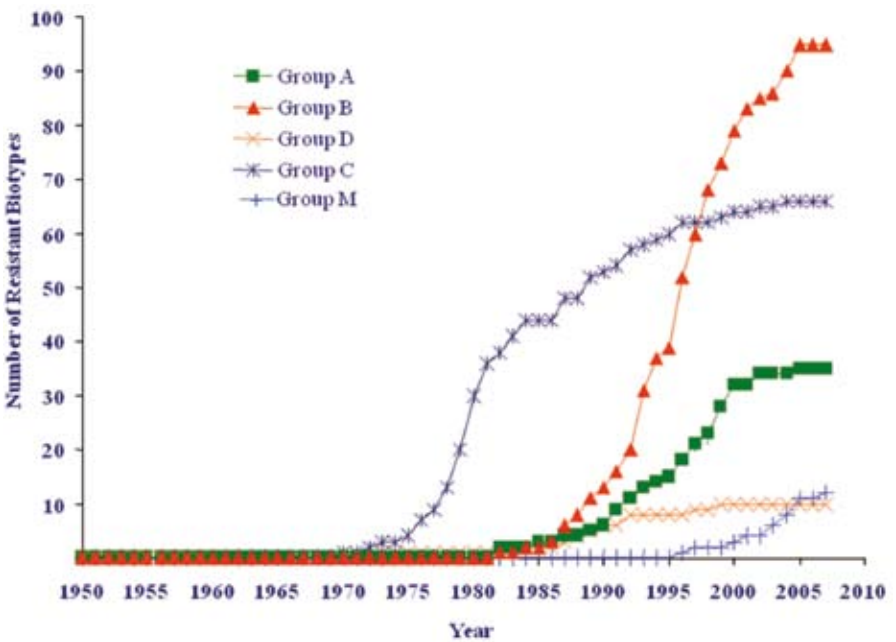
The Roundup Ready and Roundup Flex cotton crop management plan (incorporating the resistance management plan) has been developed in conjunction with leading weed scientists and industry organisations. One requirement of the crop management plan is that surviving weeds identified in the weed audits must be controlled by alternate methods prior to them setting seed. This requirement stops the survival of potentially resistant weeds in the cotton system. Since Roundup Ready cotton was first planted in 2000 there have been no identified cases of glyphosate resistance in this cropping rotation.

SUMMARY

Long-term field research and commercial experience confirms that the implementation of effective weed management strategies is the key to managing all types of herbicide resistance. Integrated weed management strategies should be developed on a case-by-case basis, considering the nature of the herbicide active ingredient, crop agronomics, biology of target weed species and available alternatives for control. The maintenance of diversity in weed management systems is crucial for glyphosate to be sustainable and glyphosate is essential for present and future world food production.

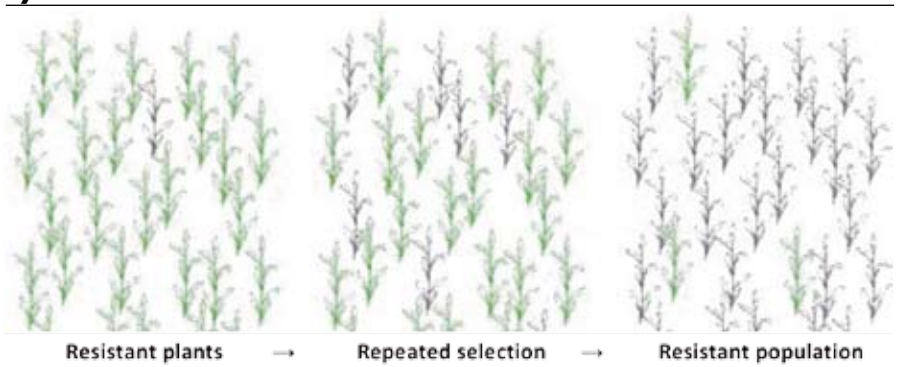
Through extensive resistance management plans, Monsanto is committed to maintaining this diversity in weed control and maximising the value of Roundup Ready traits and Roundup herbicide in the Australian agricultural landscape into the future.

FIGURE 1: Development of herbicide resistance world wide in different herbicide groups



Adapted from Ian Heap *www.weedscience.com*
*Group D cases do not include chlorthal, **Group C cases only includes triazines, does not include ureas, nitriles, etc, ***Glyphosate is a Group M Herbicide.

FIGURE 2: Change in resistant plant frequency in the farming system



RESISTANCE DEFINED

The Weed Science Society of America defines herbicide resistance as being "the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. In a plant, resistance may be naturally occurring or induced by such techniques as genetic engineering or selection of variants produced by tissue culture or mutagenesis." This criteria sets the basis for resistance but does not relate it to any in-field practical significance. The additional criteria incorporate both scientific and practical considerations which are important – for example, the failure of a herbicide to act against a weed that it is not labelled because it is not agriculturally important, although it may be scientifically interesting.

Herbicide resistance present at a low level can also be established using these criteria. This is important as when a weed population starts to develop resistance, it responds favourably to a change in tactics for only a small period of time after detection, if the initial population is to be controlled. After this, understanding that a weed population has developed resistance means that management strategies need to be tailored to minimise the potential spread of the resistant weed and the impact of the resistance on the cropping system.