Managing weeds in cotton and grain systems, optimising residuals for efficacy and minimising crop impact

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Take home message

- Residual herbicides are an important part of diverse weed management programs to provide alternative modes of action, and to reduce the numbers of weeds exposed to post-emergent herbicides
- It is important to understand the properties of the herbicide and associated plant back restrictions. Most of this information is contained on the label
- Be aware of high rates of herbicides (including post-emergent) used through sensor sprayers as there may be detrimental effects on the following crop.

Residual herbicides

Since the adoption of no- and minimum-tillage farming systems, the majority of weed management in northern cropping systems has relied on post-emergent herbicides, and predominately glyphosate. The development of glyphosate-resistance in several major weeds, and Group 1 resistance in grasses, has the grains and cotton industries looking for effective alternatives. Pre-emergent herbicides are one of those alternatives, that when used correctly can enable the use of different modes of action, provide extended control of weed populations, and reduce the number of weeds exposed to post-emergent herbicides such as glyphosate.

Some potential drawbacks of pre-emergent herbicides can include long plant-backs to some crops; the need for some herbicides to be incorporated either mechanically or by rainfall within set time periods; sufficient moisture requirements for uptake; and prolonged persistence under dry conditions.

There are several factors to consider before including pre-emergent herbicides into the weed management program. These include:

- The product label should always be the first point of reference for plant-back periods and requirements for incorporation, mechanical or by rainfall.
- The planned future crop sequence. It is necessary to consider, not only the immediate crop after the herbicide is applied, but also the crop after that when using some products.
- The label plant-back information assumes a ‘normal’ season. Plant-backs may be much longer in dry seasons than the label suggests.

- What weeds may be present (now and in the future) and where their seeds are in the soil profile.
- Getting the herbicide to the soil so that it can be incorporated and then bound. Herbicides, such as trifluralin and pendimethalin, bind tightly to stubble. Large soil clods will limit the evenness of distribution of residual herbicides and result in uneven control.
- The mobility of the herbicide is determined by its solubility in water, its binding coefficient (how much is bound to the soil vs available in soil solution) and the soil type. Herbicides that are readily soluble in water and do not bind strongly such as imazapic and metsulfuron, require little rainfall for incorporation and move easily with soil water. Table 1 contains some examples.
- The soil type. Heavier (higher clay content) soils with a higher cation exchange capacity (CEC) will bind more herbicide than lighter soils with a lower CEC. For example, to achieve the same level of control, the applied rate of trifluralin needs to increase (as per the approved label) as the clay/CEC content in the soil increases.
- How best can the herbicide be kept where it is needed, away from crop seeds and near weed seeds. Mobile herbicides (high solubility, low binding) will be easier to wash off stubble and are better suited to controlling seeds germinating from depth e.g. after cultivation. But they will be subject to leaching and runoff, while also likely to come into contact with the germinating seedling and are therefore more likely to result in crop injury. Conversely, low mobile products may stay closer to the soil surface and may work well in zero till fields where the weed seed is on the surface, with a well set up planter being able to move the herbicide away from the seed row which can increase crop safety. However, low mobile herbicides may not provide control of weeds germinating from depth and often may have reduced weed control if the soil surface dries. Most herbicides take 2-3 days to bind to the soil. Therefore, it is important to avoid applications before heavy rainfall events, as rainfall can concentrate the herbicide around the seed and cause significant crop damage.
- It is also important to have knowledge of rainfall patterns in your region in general. Several herbicides have specific rainfall amounts and events on label to complement plant back periods.
- The rate of herbicide applied using sensor sprayers may be much higher than standard broadacre rates. Consequently, the plant-back period on these patches can be much longer than the periods indicated by the label when using broadacre application rates. Use of high rates of some products through sensor sprayers can cause patches of poor establishment or damaged crop throughout a field.
- Most herbicides are broken down by soil microbes which will be more active in prolonged warm and moist conditions. Consequently, breakdown will be faster in warm, moist soils, compared with cool, dry soils. While prolonged dry periods with limited days of high intensity storm rainfall may lead to a rainfall target on a label being met, caution is advised as such conditions are not conducive to sustaining the prolonged periods of microbial activity needed to breakdown a herbicide residue. In such conditions, re-crop intervals may be longer than specified on the product label.

- Bed formation is also critically important. Aim to have the top of the bed rounded to encourage rainfall to run off the bed. Beds that have a "V" type trench above the seed will encourage rainfall to concentrate herbicide around the seed zone, damaging germinating seedlings.

Table 1. Examples of solubility and binding of selected pre-emergent herbicides.

Herbicide	**Solubility (mg/L at 20°C)**	**Average binding coefficient (K_{oc})**	**Comments**
trifluralin	0.22	15 800	Low solubility; likely to bind to soil and organic matter
pendimethalin	0.33	17 491	
flumioxazin#	0.8	889	Low solubility; slightly mobile
diuron	36	680	
isoxaflutole	6	145	Low solubility; moderately mobile
terbuthylazine	7	230	
prometryn	33	400	
S-metolachlor	480	200	Moderate solubility; moderately mobile
picloram	488	13	Moderate solubility; very mobile
saflufenacil	2100	9-55	High solubility; mobile – very mobile
imazapic	2230	137	High solubility; moderately mobile
metsulfuron	2790	12	High solubility; very mobile

*Note most of these herbicides also have rainfall requirements. Refer to the labels.

Plant-back periods

Plant-backs may be longer than indicated by a label when multiple herbicides are applied over time. The more herbicides used, the longer the plant-back period of the combination could be. For example, in an experiment at Narrabri repeated over 3 seasons, cotton was planted after 8 different in-crop (wheat or chickpea) herbicide treatments followed by 9 different in-fallow herbicide treatments. None of the in-crop treatments damaged the following cotton if glyphosate was the only in-fallow herbicide applied. Two of the in-fallow herbicides damaged the cotton. However, several of the in-crop followed by in-fallow combinations caused damage even though the same herbicides when used alone didn't cause damage. For example, Starane® Advanced herbicide applied in wheat followed by Sharpen® herbicide applied in the fallow prior to cotton (Table 2).

Table 2. Effect of the combination of wheat and fallow herbicides on subsequent cotton yield.

In-wheat herbicide (16 months prior to cotton)	In-fallow herbicide (5 months prior to cotton)	Cotton yield (bales/ha)
nil	nil	10.7 s.e. 0.28
900 mL/ha Starane® Advanced	nil	11.3 s.e. 0.26
nil	34 g/ha Sharpen®	11.6 s.e. 0.49
900 mL/ha Starane® Advanced	34 g/ha Sharpen®	9.9 s.e. 0.41

In another example (Table 3), there was a similar effect with the combination of Hussar® OD and Starane® Advanced in one season using the same design as the previous example. There was no problem with this combination in the other two seasons.

Table 3. Effect of a different combination of wheat and fallow herbicides on subsequent cotton yield.

In-wheat herbicide (15 months prior to cotton)	In-fallow herbicide (3 months prior to cotton)	Cotton yield (bales/ha)
nil	nil	8.6 s.e. 0.99
100 ml/ha Hussar® OD	nil	8.3 s.e. 1.18
nil	900 ml/ha Starane® Advanced	9.5 s.e. 1.61
100 ml/ha Hussar® OD	900 ml/ha Starane® Advanced	4.5 s.e. 1.89

Note. The Starane® was applied to a wet soil and had 66 mm rain prior to planting the cotton.

Plantbacks and optical spot sprayers

A potential issue with sensor spray applications is that applied herbicide rates may be much higher than standard rates, especially if two or three nozzles are triggered by a large weed. Such situations may kill emerging cotton plants in these spots of higher herbicide rates. Trials have observed up to 99% loss of stand, resulting in a 90% yield loss. Patches with poor crop establishment could be a symptom of residual damage from high rates of herbicide applied via a sensor sprayer during the preceding fallow and will be very costly. A 90% yield loss over 15% of a field equates to an average loss of 14%, or slightly more than 1 bale/ha, loss over the whole field.

Herbicide movement off the farm

The proximity of north Queensland cropping to the Great Barrier Reef only serves to increase the need to minimise herbicide movement off the farm into waterways. Herbicide movement off the treated area is unacceptable. It impacts water quality and reduces weed efficacy. Herbicides with high water solubility will easily move with water through the soil profile or with heavy rainfall in surface runoff from the treated area into waterways. Delaying herbicide application when heavy rainfall events are imminent, will minimise movement of water-soluble herbicides.

Herbicides that bind to the soil will move with soil particles in runoff during significant rainfall events. Preventing soil movement is harder and involves either earthwork or providing adequate ground cover of vegetation buffer zones between the field and waterways to filter soil particles.

For example, with diuron the label attempts to address this. Use is restricted to land with less than 3% slope, use in cotton or channels is restricted to fields where run off from irrigation or up

to a 25mm storm can be captured and held on farm. For sugarcane uses in north Queensland, application is restricted to times of the year when there is a lower change of storm runoff.

Groundcover in the form of stubble cover or cover crops and in cracking clays, maintaining soil cracks from no-till practices, greatly reduces the extent of likely soil erosion and surface runoff. However, surface cover also affects the ability of herbicides to get to the soil and requires the use of more water-soluble herbicides that are less likely to bind to stubble. It is important to remember that it typically takes 2-3 days for incorporated herbicides to bind to soil particles; this timeframe must be considered when heavy rainfall events are imminent.

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