Understanding the "critical period for weed control" concept

By Graham Charles and Ian Taylor, NSW DPI and Cotton Catchment Communities CRC

The past few years have brought new innovations in weed management in the Australian cotton industry. These include the transgenic options of Roundup Ready, Roundup Ready Flex and Liberty Link cottons, the post-emergence, over-the-top herbicides Staple and Envoke, and more accurate inter-row cultivation, with additional options likely over the next decade.

These new options allow growers to develop more effective and flexible weed management programs, but the old dilemmas still remain. Growers have to answer the questions:

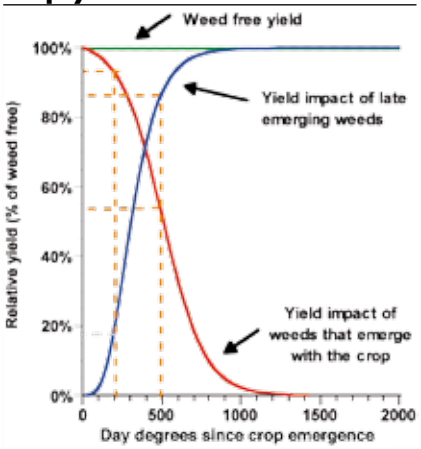
- Should I use multiple pre-emergent herbicide applications, with pre-planting as well as at-planting herbicides?
- Or maybe just one of the options, but if so, which herbicide/s and at what rates, broadcast or banded?
- When should I inter-row cultivate or chip, or should I just apply another herbicide? or,
- Should I use a layby?

Using more and more herbicides gives better weed control, but pre-emergence residual herbicides can contribute to establishment problems and additional post-emergence herbicides will not necessarily result in better yields, or improved returns. In fact, controlling weeds in a fairly clean field may just reduce profits.

Conversely, inadequate weed control can be costly to remedy, and can result in lost yield and weed problems for years to come. So the question is, what herbicide/cultivation/chipping combinations will give optimal weed control, and maximise yields and returns?

The answers are complex and vary from field to field and season to season.

FIGURE 1: The impact of four thornapples per metre on crop yield



The orange lines demonstrate the impact of control 200 and 500 day degrees after crop emergence.

A WEED CONTROL THRESHOLD

Post-emergence herbicides, such as glyphosate, bring the advantage that they are applied to a known weed population. This allows the choice of herbicide, rate and application timing to be targeted to the weed population. These herbicides can substitute for pre-emergent residual herbicides, cultivation and chipping inputs to maximise weed control and minimise costs.

But the application timing of post-emergent herbicides remains an issue. Growers must balance spraying too often, which provides good weed control — but increases cost and selection pressure for herbicide resistance and species shift — against spraying too little. Delaying control may save costs by reducing the number of applications needed over the season, but increases the risk of weed escapes that can be costly to control, and may lead to yield losses and a build up of weeds over time.

A weed control threshold is needed to help balance the pressures of spray efficacy and cost. The threshold must take into account the characteristics of the weeds, their density and the control options available, to provide guidelines on if and when a weed population should be controlled.

DETERMINING THE ECONOMIC THRESHOLD FOR WEED CONTROL

The decision to control a weed is influenced by crop growth stage, the availability of suitable herbicides, labour and equipment, the weather; and financial aspects such as lint price, expected yield, and the cost of weed control. The actual level of the economic threshold (the critical number of weeds that triggers a grower to control a weed infestation) is a personal choice reflecting how much loss a grower is willing to tolerate before deciding to control the weed.

For example, a grower may consider using a Roundup Ready herbicide application costing around $23 per hectare, including application. The grower will probably not use the herbicide unless the weeds will cause at least a $23 per hectare yield loss, with additional benefit expected in harvest efficiency, lint quality and reduced weed problems in later years.

At a bale price of $380 and an expected yield of eight bales per hectare, this establishes an economic threshold for applying Roundup Ready herbicide at around 0.8 per cent yield loss. That is, the economic threshold is 0.8 per cent level of yield loss.

The economic threshold is easily established. The trick is in being able to quantify the yield loss caused by the weeds.

UNDERSTANDING THE IMPACT OF WEEDS

A weed control threshold must take into account the characteristics of the weeds, their density and the control options available. Competitive ability is one of the more important characteristics of a weed, but other features, such as the ability to host insect pests and diseases, seed production, and lint contamination potential are also important.

The competitive ability of a weed relates to its growth rate and architecture (height, shape, leaf size, branching characteristics, root structure, rooting depth and so on), and varies with each weed species. Generally, smaller weeds are less competitive, and large weeds, such as noogoora burrs, are highly competitive.

The competitive impact on a crop is also affected by the time the weed emerges and the time of the weed's removal. Weeds that emerge late in the season may have little impact on the crop's yield, whereas even relatively uncompetitive weeds that emerge with the crop are likely to impact on yields if not controlled.

DETERMINING THE YIELD LOSS FROM WEEDS

The impact of weed competition on crop yield is demonstrated in Figure 1, generated from a field population of four thornapples per metre of cotton row.

In Figure 1, the green line across the top is the yield if there were no weeds in the field (the weed free yield).

The red line is the yield loss from a thornapple infestation where the weeds emerged with the crop and were removed some time after emergence. For example, if the thornapples were controlled at 200 day degrees, crop yield would be reduced to 93 per cent, a seven per cent yield reduction (indicated by where the orange line at 200 day degrees hits the red line).

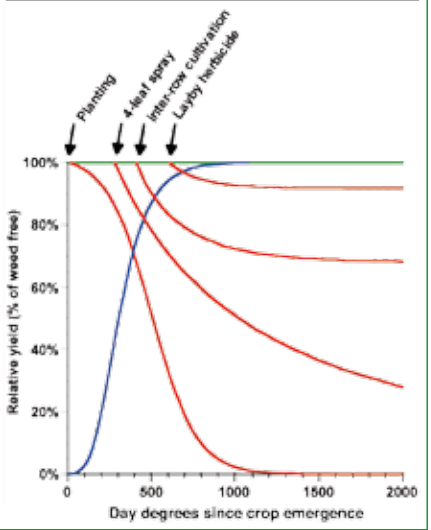
If the thornapples were removed at 500 day degrees, the yield would be reduced to 54 per cent, a 46 per cent yield reduction (500 degrees days orange line). Yield would be reduced by 100 per cent if the thornapples were not controlled before 1300 day degrees.

The blue line is the yield loss from a thornapple infestation where the weeds emerged after the crop and were not subsequently controlled. If, for example, thornapples emerged at 200 day degrees and were not controlled, yield would be reduced to 18 per cent, an 82 per cent yield reduction (where the orange line at 200 day degree hits the blue line). But if the thornapples didn't emerge till 500 day degrees and were not controlled, the yield would only be reduced to 86 per cent, a 14 per cent yield loss.

Although a single red line is shown for simplicity in Figure 1, there would actually be a family of red lines, representing

...50 ▷

FIGURE 2: The impact of weed competition on crop yield following weed control inputs



thornapples that emerged after each weed control input (inter-row cultivation, herbicide and so on), as shown in Figure 2.

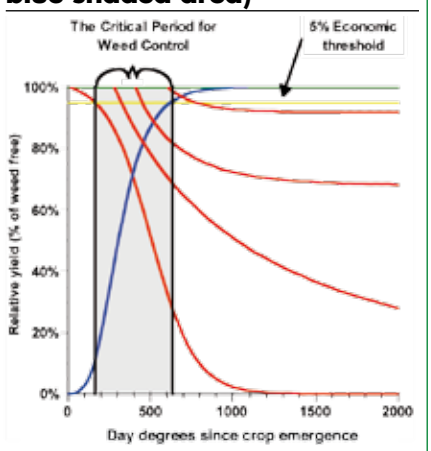
A further set of lines would be needed to show the impact of thornapples at another density, and still more sets of curves to show the impact of other weeds, as the curves are different for each species and density.

THE "CRITICAL PERIOD FOR WEED CONTROL"

A concept known as the "critical period for weed control", can be derived from the interaction of these relationships with the economic threshold for weed control.

The "critical period for weed control" starts at the intersection of the first red line with the economic threshold (yellow line), and ends with the intersection of the blue line with the economic threshold, as shown in Figure 3. A new "critical period for weed control" is defined after each weed control input, beginning where each subsequent red line intersects with the economic threshold. The end of the critical period does not change.

FIGURE 3: Deriving the "critical period for weed control" (the blue shaded area)



The "critical period for weed control" is defined by the economic threshold chosen, the weed species and the weed density. In this example, the "critical period for weed control" for four thornapples per metre of cotton row is 166 to 621 day degrees at a five per cent economic threshold. Thornapples not controlled during this period will cause economic yield loss.

BEYOND THE "CRITICAL PERIOD FOR WEED CONTROL"

A strength of the "critical period for weed control" concept is that it clearly defines the period during which weed control is required, and conversely, the periods during which weeds cause insufficient yield loss to justify their control. Figure 3, for example, shows that where thornapples emerged with the cotton crop at four plants per metre, there is no justification for controlling them before 166 day degrees of crop development.

Conversely, if up to four thornapples per metre establish after 621 day degrees, they would not cause an economic yield loss (using a five per cent yield loss threshold). But they might still need to be controlled to avoid seed production, harvesting difficulties and thornapple problems in later seasons.

This information is especially important for the management of relatively clean fields where weed control decisions can be difficult to make, as it may be unclear whether a weed density is sufficient to justify control.

But the "critical period for weed control" concept has several weaknesses. It assumes that weeds are equally easily controlled at all growth stages, that the cotton grower has the capacity to control all weeds at the required time, and that the weeds have no negative impact except on crop yield. Weed control decisions may also be justified for irrigation and harvesting efficiency, to reduce pest and disease carryover, to prevent lint contamination, and to prevent weed seed set, reducing future weed burdens.

Also, the "critical period for weed control" is affected by the economic threshold adopted. At a one per cent yield loss (economic) threshold, compared to a five per cent economic threshold, for example, the critical period in Figure 3 extends from 61 to 818 day degrees after crop emergence. At this threshold, the first-post-emergence treatment would occur while the crop was at the one node stage, and subsequent treatments would need to occur within a week or so of weed emergence to avoid reductions in crop yield.

TIMING OF HERBICIDE APPLICATIONS

Application timing is critical to achieving good results with post-emergent herbicides. Herbicides should be applied when they will provide effective control and before weeds begin to reduce crop yield potential, ideally at the start of the "critical period for weed control" (Figure 3). Best control with herbicides is obtained when weeds are small, when there is adequate soil moisture and when temperatures are ideal.

But the germination of weed seeds is mainly governed by temperature and soil moisture conditions, (it may also be influenced by seed dormancy). So there are normally a number of weed flushes throughout a season following rainfall and irrigation events.

Cotton growers must take into account the likely number of germination events, the cost of weed control, the capacity to cover a number of fields with the application equipment available, and possible yield reductions due to weed pressure when making a weed control decision. Control of very small weeds prior to the weed removal time would be efficient in terms of herbicide, as lower rates are required to control smaller weeds, but may be very inefficient if subsequent germinations quickly replace the previous weed population, requiring repeated treatments.

PREVENTING WEED SEED SET

The aim of weed management is to minimise economic loss in the current crop, but also to protect future crops by preventing weeds from setting seeds and adding to future weed problems. To achieve this, weed management strategies may need to continue beyond the "critical period for weed control".

But rather than focusing on controlling the weeds, emphasis needs to be placed on preventing those weeds from setting seed. This may be achieved using a lay-by herbicide, or with spray topping, where a sub-lethal dose of herbicides is applied to cause weeds to abort seed or to set non-viable seed. Defoliants or Roundup applied at or prior to defoliation may also help to reduce seed set. Further research is needed to confirm the value of these options.